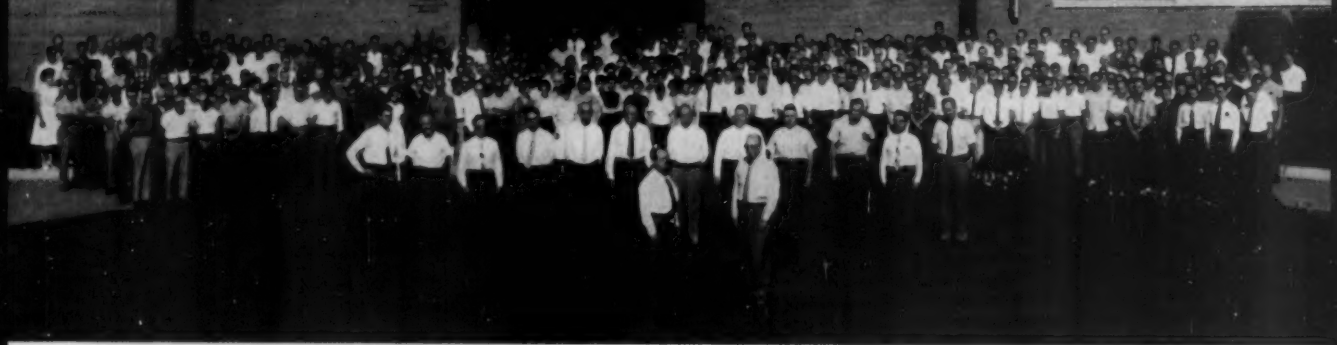
PRODUCT ENGINEERING

GRAW-HILL WEEKLY FOR DESIGN ENGINEERS · DECEMBER 5, 1960



ENGINEERS OF THE JOHN DEERE TESTING AND RESEARCH CENTER, WATERLOO, IOWA . . .

. . . DESIGNED THIS NEW TRACTOR LINE 'FROM THE GROUND . . . FOR TECHNICAL DETAILS SEE PAGE 78

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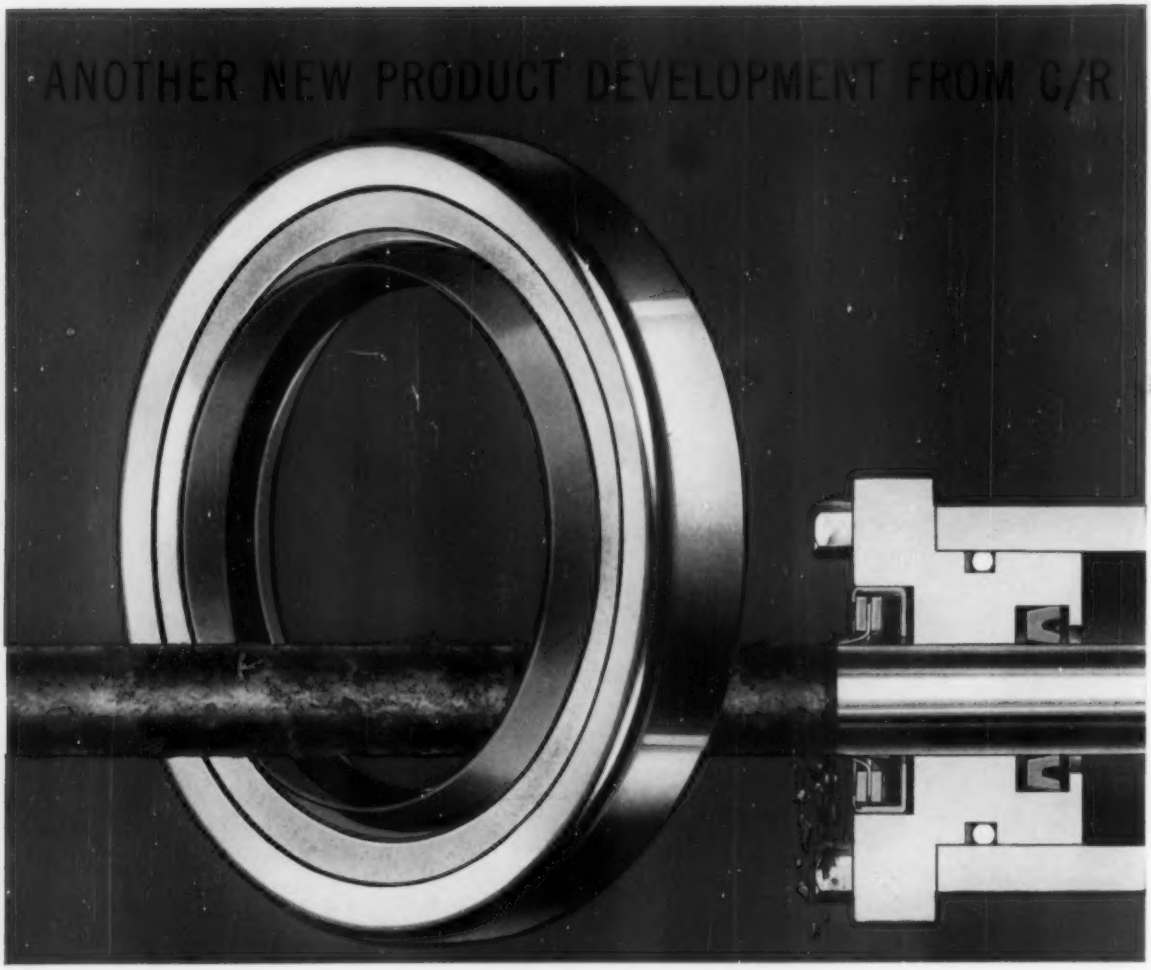

New Wiper-Scraper Seal for Cylinders

Scrapes off ice, mud, tar – wipes off water, dust, other contaminants

Now, you can effectively exclude dirt and other contaminants from hydraulic cylinders under the most severe field conditions. One compact unit, the C/R SC Wiper-Scraper Seal does the job. Formerly, a separate rod scraper had to be installed in front of the ordinary wiper seal. The special machining necessary, plus the scraper ring, and retaining ring made this an expensive installation.

Chicago Rawhide's SC Wiper-Scraper Seal combines a spring brass scraper and synthetic rubber wiping member in one steel shell. The I.D. of the scraper is slightly under shaft size to provide a snug fit that will remove tar or frozen mud, but it has sufficient play within the shell to tolerate any off-center conditions of the rod such as caused by bearing "bore-slop." The cost is much lower than any other combination of scraper and wiper. "Design-in" cost is low, assembly simple. Most important is the performance contribution to the cylinder. The additional value of longer packing life and increased operating dependability with the SC Wiper-Scraper Seal will far outweigh the nominal cost.

For complete information, specifications and standard sizes, write for your copy of C/R's new Bulletin SC-100

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Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

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Why metals corrode...and how you can prevent it

The basic cause of corrosion is the instability of metals in their refined state. Metals tend to revert to their natural states through the processes of corrosion. For example, when you analyze rust, you will find it is iron oxide. When you analyze natural iron ore, you find it, too, is iron oxide. Six forms of corrosion which can attack the equipment you design are:

1. General tarnishing or rusting with occasional perforations in highly affected areas.

2. Highly localized attack by pitting.

3. Cracking induced by a combination of stress and corrosion.

4. Corrosion confined to crevices, under gaskets, or washers, or in sockets.

5. Corrosion of one of an alloy's constituents leaving a weak residue.

6. Corrosion near the junction of two different metals.

In all of the six forms of corrosion mentioned above, corrosion has the same basic mechanism. It's similar to the electrochemical action in a dry cell.

The electrolyte in the dry cell corresponds to the corrosive media, which may be anything from the moisture in the air to the strongest alkali or acid.

The plates of the battery correspond to the metal involved in corrosion.

A potential difference between these metals or different areas on the same metal causes electricity to flow between them through the electrolyte and a metallic bridge or contact that completes the circuit.

At the anode, a destructive alteration or eating away of metal occurs when the positively charged atoms of metal detach from the solid surface and enter the solution as ions.

The corresponding negative charges, in the form of electrons, travel through the metal, through the metallic bridge, to the cathode.

Briefly then, for corrosion to occur, there must first be a difference in potential between the metals or areas on the same piece of metal so that electricity will flow between them. Next, a release of electrons at the anode and a formation of metal ions through disintegration of metal at the anode. At the cathode, there must be a simultaneous acceptance of electrons. Action at the anode cannot go on alone, nor can action at the cathode.

CONTROLLING CORROSION

When corrosion occurs because of the differences in electrical potential of dissimilar metals, it is known as galvanic action. Differences in potential from point to point on a single metal surface causes corrosion known as local action.

When you plan against galvanic corrosion it is essential to know which metal in the couple will suffer accelerated corrosion . . . will act as the anode in the corrosion reaction.

The galvanic series table shown below can supply this information. In any couple, the metal near the top of this series will be the anode and suffer accelerated corrosion in a galvanic couple. The one nearer the bottom will be the cathode and remain free from attack or may corrode at a much slower rate.

GALVANIC SERIES TABLE

Magnesium
Magnesium alloys
•
Zinc
•
Aluminum 25
•
Cadmium
•
Aluminum 17ST
•
Steel or Iron, Cast Iron
•
Chromium-iron (active)
•
Ni-Resist
•
18-8 Stainless (active)
18-8-3 Stainless (active)
•
Lead-tin solders
Lead, Tin
•
Nickel (active)
Inconel* (active)
•
Brasses, Copper, Bronzes
Copper-nickel alloys, Monel
•
Silver solder
•
Nickel (passive)
Inconel (passive)
•
Chromium-iron (passive)
18-8 Stainless (passive)
18-8-3 Stainless (passive)
•
Silver
•
Graphite, Gold, Platinum

HOW TO USE THE CHART

Notice how the metals are grouped in the galvanic series table. Any metal in one group can be safely used with any other metal in the same group. However, when you start mixing metals from different groups, you may run into serious galvanic corrosion of the metal higher on the list. And the further apart these metals are listed, the worse this corrosion may be.

But, if you have to mix metals, pay particular attention to the electrical contact between them. Eliminate any metallic bridges or contacts of metal to metal that will permit the flow of electrons through them. You can do this by separating the metals physically, or by using insulation or protective coatings. Another factor is the relative areas of the metals in contact with each other. Parts having the smaller area should be of a metal with a lower listing on the galvanic series table than the metal used for the larger area.

When you plan against local action, remember that the corrosion process is galvanic: Electrons move from one point in the metal to another. One of the easiest ways to prevent local action is to use a metal with little or no impurity. When alloys are involved, make sure the constituents are closely listed in the galvanic series table. Local action may also be stopped by the use of protective coatings, which shield the metal from the corrosive media. Environment must also be considered, for its nature may be an important factor in either promoting or restricting corrosion.

TECHNICAL ASSISTANCE

As you can see, many factors are involved in both local and galvanic action. That's why it's best to bring your metal problem to Inco's Corrosion Engineering Service. Available data will be furnished wherever possible . . . tests will be made where needed. Inco's Corrosion Engineering Service will be glad to apply principles of corrosion control to your specific problem.

LITERATURE

The publications listed below will provide more detailed information on how you can combat corrosion by using nickel-containing metals.

Publication Number	Name
A232 . . .	Corrosion Problems in Nuclear Reactor Power Stations
A59	Factors of Importance in the Atmospheric Corrosion Testing of Low-Alloy Steels
A62	A Theory of the Mechanism of Rusting of Low-Alloy Steel in the Atmosphere
A137 . . .	Corrosion by Some Organic Acids and Related Compounds
A144 . . .	Some Observations of the Potentials of Stainless Steels in Flowing Sea Water

A complete list of the 187 Inco publications and technical bulletins on nickel-containing metals can be obtained by writing for "List A", to:

*Registered trademark

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N.Y.

INTERESTING TO NOTE

On our cover—a new tractor, and the men who developed it: the personnel of John Deere Research and Engineering Center, Waterloo, Iowa. Below is a closeup of some of the key men in this new-product project. (For more details, see page 78.)

This tractor is a comparative rarity—a really new product, not just an improved version of an existing model. It resulted from an order to the company's product engineers to "throw away the book" and develop a new line of tractors. The thoroughness with which they did their job is shown by the fact that of the 65 patents backing up this new tractor line, 50 are new.

CLOCKWISE: Knud Sorensen, assistant chief engineer, Industrial Tractors; Jerry Smelzer, supervisor, Planning Dept; Waldo Seiple, head of Development Research; Donald Wielage, executive engineer; Merlin Hansen, chief engineer, New Products; W. H. Nordenson, assistant chief engineer, Factory Contacts; Emil Jirsa, assistant chief engineer, New Products.

Tractors made their first appearance on the farm around the 1860s. In those days, they were steam-operated power packs used to run threshers. At first they were pulled from farm to farm by horses, but later models were self-propelled. Almost immediately, the inventive began to dream how they might apply the engine's power to other farm equipment; and in 1860, an Illinois farm journal reported what it called "the first actual success in steam plowing in America." This tractor plowed 2½ acres in 72 minutes, if you didn't figure in time for breakdowns.

Gas traction engines which followed were lighter and more efficient but still pretty clumsy by today's standards. "Old No. 1," completed in 1901, weighed 10 tons and was rated at 22.45 hp. Obviously a machine this big and bulky didn't fare too well on steep slopes or muddy fields. The trend toward lighter weight tractors began around 1905, and in 1908 appeared a single-cylinder machine weighing only 5 tons. Actually the word "tractor" meant nothing to the public until the 1906-07 season when it appeared in a manufacturer's advertisement as a shorter way to say "gasoline traction engine."

The period following World War I saw the real birth of power farming. The "crawler" of the Best and Holt Companies (later merged into the Caterpillar Tractor Co) received prominence during World War I as an armed tank that "laid its own rails." By 1918, tractors were laid out on drawing boards and designed for mass production.

continued, next page

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Since then they have found wider and wider application. In 1920, the US Dept of Agriculture said that there were 246,000 tractors on our farms and 25.7 million horses and mules. By 1950, there were 4 million tractors and 7 million horses and mules.

Inside Advice on Being Out

Many of us will remember listening during World War II to Toscanini conducting the General Motors Symphony of the Air on Sunday afternoons. Sandwiched between the music, GM's famed C. F. Kettering delivered a five-minute talk on science and invention. "Boss Kett's" intention was to share some of his philosophy on science and engineering with a vast Sunday audience. (On page 76, today's engineer shares his experience with engineers of tomorrow.) Kettering was first to point to the importance of research in industry. He believed that "in many ways, ideas are more important than people—they are much more permanent." As an example, he told his radio audience how a 2500-year-old idea enabled Diesel to build his engine.

It seems that many years ago, natives on the island of Samoa, seeking another way to start a fire, hit upon a new idea. They carefully fitted a wooden plunger to a small hollow section of bamboo that was closed at one end. Then they put a piece of dried moss on one end of the plunger and placed it in the hollow section. Pushing the plunger down compressed the air in the cylinder. If this was done very quickly, the air, heated by compression, ignited the moss. Diesel saw one of these South Sea "pocket lighters" in Augesburg, Germany and his idea for the compression ignition engine was born.

Kettering emphasized the importance of research before it became fashionable. His advice to young engineers: "Maybe one of the reasons people are so easily discouraged, when conducting research, is because of their education. During all of our years at school, we were examined two or three times a year. If we failed once, we were out. In contrast, all research work is 99.9% failure and if you succeed once you are *in*. If we are going to progress in any line we must learn to fail intelligently so we won't become discouraged at the 99.9% failure."

Benedict A Leerburger Jr

SIDELIGHT

The conflict between man and machine was recently renewed on the New Jersey Turnpike. The Turnpike Authority started it by spending $12,000 for an automatic card dispenser. As the motorist entered the parkway he was supposed to push a button and remove an outthrust card indicating his "port of entrance." But many drivers thought this timesaver was an automatic toll collector and tried to pay it. Quarters were hurled at the machine . . . money was neatly stacked atop it . . . one driver tried to cram a dollar bill into the card slot. Other motorists, seeing no human toll collector, sped past the device—and then, upon leaving the turnpike, had to pay more toll than they owed. The Turnpike Authority has now called it quits, is going to spend $15,000 for a new machine—one that will spit out a card when the car crosses a treadle.

NEXT WEEK IN PRODUCT ENGINEERING

. . . Today's Ball Bearings—Here's the Choice

More than 40 distinct ball bearing configurations are tabulated, described and illustrated in this Special Report on precision and commercial bearings. The more common ones are also compared in a table.

. . . Sampling Theory

How well does a sample represent the whole? Here's an explanation of the equation and a graphical plot to speed computation.

. . . Easier Way to Find Trapezoidal-spring Deflection

For calculation purposes, if "converts" the trapezoidal to a constant-thickness spring.

. . . Creativity—a New Appraisal

Extracts and ideas shed light on the twin problems of industry vs the creative man, and a society that is conservative yet seeks innovation.

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DEVELOPMENTS TO WATCH . . .

Supercold brings "no-loss" motor

Motors that can run indefinitely with almost no losses have moved from pipe dream to prototype at General Electric's General Engineering Laboratory. An outgrowth of its work on cryogenic bearings (*PE—Feb 8, p 20*), the superconducting motors will operate in liquid helium, helium gas, or high vacuum, using superconductive rotor surfaces against which magnetic bearing forces are applied.

Torque can be produced either by alternating or pulsed dc flowing in the superconducting windings around the rotor, and it is proportional to the second power of the stator current. Synchronization of pulses can be controlled by rotor position-sensing pickoffs; both optical and inductive means are being devised for the purpose. Furthermore, conventional motor excitation and control circuitry, located outside the cryogenic system, and operating at room temperature, can be used.

Units have been operated in vacuum at speeds to 20,000 rpm; and K. F. Schoch of GE says "if motor losses occur, they are not of sufficient magnitude to produce a loss of superconductivity or a loss of suspension and motor torque."

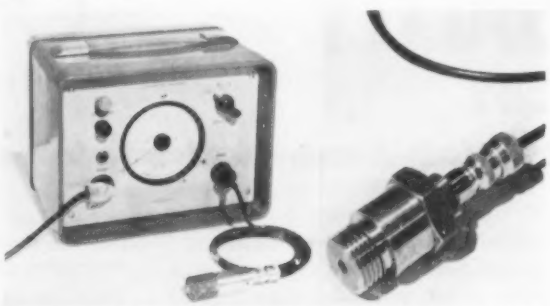
Models so far built are shaftless types. A direct shaft output is considered feasible if the motor is to operate another device which is at cryogenic temperatures. But, says Schoch, the heat-transfer and sealing problems met in connecting the shaft to a room-temperature device would "appear to negate any advantages which could result from operation of a frictionless motor of unusually high efficiency."

Low-cost process promises high-quality lubes

Lubricating oils offering "excellent resistance to oxidation" are promised by a new, lower cost treatment-process developed at British Petroleum Ltd (Dunkirk, France and Sunbury-on-Thames, England). Soon to go into production at Dunkirk, the new "Ferrofining" process has the advantage of producing no solid byproducts—eliminating a major disposal problem and promising a significant reduction in costs. Both motor and diesel oils have been made by the new technique, and specialty products are under development. The process will be licensed for use in other countries.

New tachometer, transducer designed in Britain

A fully portable tachometer that operates on batteries or line current, and a general-purpose inductance transducer—these are two of 21 new products being introduced by Southern Instruments Ltd of Surrey to celebrate its 21st birthday.



NEW BRITISH INSTRUMENTS include tachometer (left) and transducer (right). Tachometer is made with both photoelectric and magnetic pickups.

The tachometer shown in the photo is to be made in two models, one for the range of 0 to 30,000 rpm, the other for frequencies from 30,000 to 300,000 rpm. Over-all accuracy is said to be better than 1.5%. Power requirement: 200 ma at 12 v; size: 7 x 9 x 6 in. Weight: less than 4 lb.

The transducer pictured here is said able to stand 100% overload without damage and to resist attack by corrosive atmospheres. It can operate at 300 F without cooling. For higher temperatures, a watercooled model will be available. Linearity and hysteresis are "better than 1% of full range." Pressure ranges available: 0 to 10 psi, to 0 to 10,000 psi.

(For news of other new Southern Instruments "Birthday Products," see forthcoming issues.)

continued on p 8

This New Catalog Covers Complete New Line of MARMAN Industrial Clamps, Couplings, Joints

New 44 page Catalog 803 covers Marman's greatly expanded line of industrial clamps, couplings and joints designed to solve the problems of fastening and joining fluid lines, containers, tanks, separators and similar units.

Presented specifically for design engineers is detailed product, performance and application information about Marman V-Band Couplings, FLEXMASTER Pipe Couplings in a wide range of configurations, all metal CONOSEAL Joints for leakproof pipe and tube connections under extreme pressures and temperatures, and other products. These products reduce manufacturing costs, improve product appearance and performance, speed assembly and simplify maintenance.

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Ferrous metals protected from molten alloys

Denitriding, followed by a surface treatment with zirconium in solution or molten form, can protect steel from attack by liquid metals, AEC researchers report.

Removal of the nitrogen permits diffusion of the zirconium into the metal's surface and results in a protective zirconium carbide coating. Hafnium or titanium may also be used, although they do not seem quite as effective.

The process has been patented (#2,926,111), and may be licensed from the AEC on a royalty-free, nonexclusive basis.

(Note: For more on liquid metals and their applications, see *PE*—Oct 24, p 45.)

Checkered bearings under test in USSR

"Checkered" bearing surfaces made of "pseudo-alloys" are the latest Soviet approach to providing low-cost, low-friction sliding elements.

The starting point is a bimetal bushing—a section, for example of steel or copper-lined steel pipe. The inside surface is then knurled to form depressions about 8 mm deep. These depressions are then filled with lead and a smooth lead coating is electrolytically deposited on top. The Soviets say the bearings show excellent antifriction properties, and compare favorably with cast lead-bronze bearings.

Reporting on the work, at the Byelorussian Institute of Railroad Transportation, D. M. Khayt says (in *Machinostroyeniye*) that the steel-lead pseudo-alloy, in the form of powder compacted and cast as well as checkered elements, is particularly worth further investigation. Only a brief abstract of the report is available in English. It may be found in the Soviet Technical Press Review, number 60-21441-6, available from OTS.

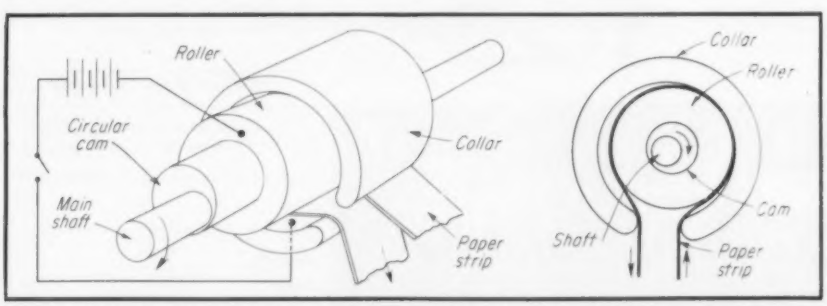
High-speed printer for high-quality reproduction

A printing mechanism that records at speeds to 50 lines a second, yet gives quality reproduction because it stops momentarily while printing, is reported by Toronto University's Computation Center.

In its simplest form (see diagram), the printer consists of a collar with a slot for paper entry and exit, a roller, and a cam. The dimensions of collar and roller are so chosen that the paper strip is pressed firmly against them along a single line of contact. Clockwise rotation of the shaft will then move the paper counterclockwise. Each rotation of the shaft advances the paper an amount equal to the difference in diameter between outside of the roller and inside of the collar. As the paper moves forward, each line of contact on the paper touches successively a series of lines on inside of the collar and remains briefly at rest as the printing is done.

The unit shown in the diagram is designed for printing with electrosensitive paper; but a solenoid-operated type-bar system may be substituted, and a variety of electronic and external storage arrangements can be provided.

Two prototype models have been built—one that prints 650 characters per sec and another, smaller unit that prints 540 per sec. Design details and licensing information can be obtained from Britain's National Research Development Corp. US Office: Suite 503, Mercury Building, 1925 K St, NW, Washington 6, DC. —ARG



PAPER-FEED MECHANISM for high-speed printer is diagramed here. Roller moves smoothly along inner surface of collar as the shaft and the cam rotate.

WHAT'S HAPPENING IN RESEARCH . . .

Carbon films head for X-ray windows

Self-supporting carbon films that can be used as "windows" in X-ray equipment have been prepared at Cornell U.

As reported by D. J. Baker to the American Physical Society, the technique involves depositing a layer of carbon on a glass slide that has been treated with a wetting agent, and then floating the layer off by immersing it in distilled water. This decalcomania-like system forms unsupported films with areas up to 1.6 cm^2, and a surface density of 48 microgram/cm^2. Thickness is approximately 2000 Angstroms. Thinner films can be made, but their area must be much smaller. A high-current vacuum arc, operated intermittently between a pointed and a flat pure-carbon electrode, was the source of vaporized carbon for film deposition.

Tests show variations in surface cleanability

Trouble with surface-finish specifications is pointed up by an Oak Ridge decontamination study. It describes two problems: Current standards tell how standard sheet and plate should be finished, but they do not give specific tolerances; and cleanability of the surface seems to vary with the thickness of the sheet as well as with the type of finish. For instance, the "decontamination factor" for $\frac{3}{16}$-in. hot-rolled, annealed and pickled stainless sheet is better (by a factor of three) than that for $\frac{1}{4}$-in. plate with the "same" finish.

As might be expected, the performance of cold-rolled plate was considerably better than that of any of the hot-rolled samples. But the type that scored highest (ORNL calls it a "2B finish") is not even produced in the US, though a fairly close approach to it is available from one supplier at a 2¢/lb premium.

For the tests, 4-in.-square specimens were dipped in a contaminant solution of mixed fission products, measured for radiation count, rinsed, and then remeasured. Then each was cleaned with nitric acid and measured again.

The "decontamination factor" was taken as the percentage drop between the initial reading and the final one. For $\frac{3}{16}$-in. hot-rolled sheet, the average was 731; for $\frac{1}{4}$-in. plate, 257; and for $\frac{1}{8}$-in. cold-rolled sheet, 1088.

Briefing the Soviet record . . .

Columbium-tin alloys are harder and have better oxidation-resistance than pure columbium, Soviet metallurgists say. The Cb-Sr compound (approximately 30% ton by weight) shows a Vickers hardness of 900, and a superconductivity transition point of about −427 F. Microstructure studies are now being made. M. I. Agafonova and coworkers at Akad. Nauk SSSR.

For producing superfine wire in sizes down to 2 microns, Soviet engineers are now using two different techniques. The original system forced molten metal through very small orifices by high-pressure air or inert gases. Now, a magnetic method is being used, and the wire is being insulated as it is made. A high-frequency magnetic field draws the molten metal up inside a very fine glass capillary tube. When it solidifies, it's all ready for use—complete with a glass sheath. An article describing the techniques appeared in *Krasnaya zvezda*, 7 July 1960. The complete English translation, however, is not yet available in this country.

For wear resistance, graphitized nylon gets a boost from Soviet engineers. They've compared friction coefficients of nylon 6, phenolic, glass-fiber-filled and glass-fiber-reinforced plastics at various shaft speeds and loads. Nylon, containing 3 to 5% graphite, far outperformed the others, particularly under conditions of poor lubrication. Reports have been published in *Izvestiya Mashinostroyeniye*, No. 3, 1960; and *Vestnik Mashinostroyeniya*, No. 5, 1960. Only brief abstracts are available in English, however.

As an electrical resistance material and for thermoelectric energy conversion, chromium disilicide rates further attention, say researchers at the Soviet Physical Chemistry Institute. Noting that similar compounds of silicon with other metals show a high thermal electromotive force and good resistance to oxidation when heated in air, they've been studying conductivity-temperature relationships and chemical composition; and recommend (in an article in *Neorganicheskoy Khimii*, vol 5, 1960) further work on both aspects. —ARG

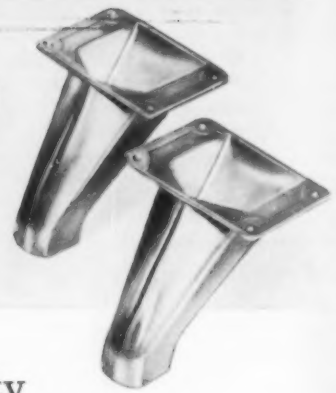
Hi-temp thermocouples bend to fit test parts

For applications requiring more flexibility than is attainable with standard ceramic sheaths, the Johnson Matthey Company of England offers a metal-sheathed, mineral-insulated thermocouple assembly that can readily be bent around a small radius, and is easily attached to test parts.

Standard construction uses a sheath of 10% rhodium-platinum alloy on a pure nickel or stainless base. Standard sizes are 0.065 in. and 0.125 in. OD. The wires may be any one of several rhodium, platinum, or iridium combinations; and, JMC says, the couples are serviceable to 3000 F or above "in all normal industrial atmospheres," and will resist attack by molten glass and other materials that dissolve ceramic sheaths.

FLEXIBILITY of metal-clad thermocouples is illustrated here. Note special end-cap designed to prevent chafing and short-circuiting.

Steel furniture manufacturer gets **these 5 benefits** from Mt. Vernon die castings



CASE HISTORIES FROM MT. VERNON FILES

Subject:

Art Steel Company, New York City

In a major switchover, Art Steel Company makes this handsome Steelmaster Desk with aluminum die cast legs. The companion Executive Chair stands on a die cast aluminum base. Formerly it took 8 parts to assemble each island leg of the desk . . . and 14 parts for the chair base. But switching to die cast parts gave Art Metal Company 5 major benefits:

1. Simpler fabrication since all castings are one-piece integral units. No more multiple section subassembly work.

2. Complete freedom in designing due to the many inherent advantages of the die casting process.

3. Corrosion of legs and bases caused by office cleaning detergents no longer a problem. Aluminum die castings stay bright and attractive.

4. Die castings are delivered polished, drilled and tapped, ready for use. Several assembly steps previously required have been eliminated.

5. Because production of legs and bases has been put into Mt. Vernon, valuable production capacity at Art Steel has been freed for other requirements.

More and more, in a great variety of products, Mt. Vernon Die Castings are replacing complex sheet metal assemblies and costly, crude sand castings, bringing significant production economies to the manufacturer. All the knowledge we have gained on this subject is also available to you . . . free. Why not discuss your problem with us too. A call to your nearest Mt. Vernon representative will bring you action.

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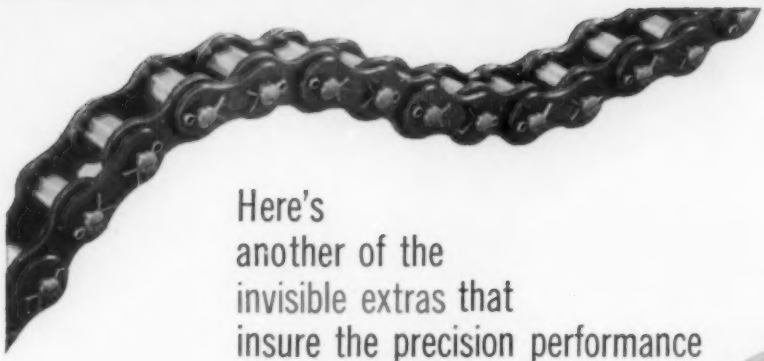
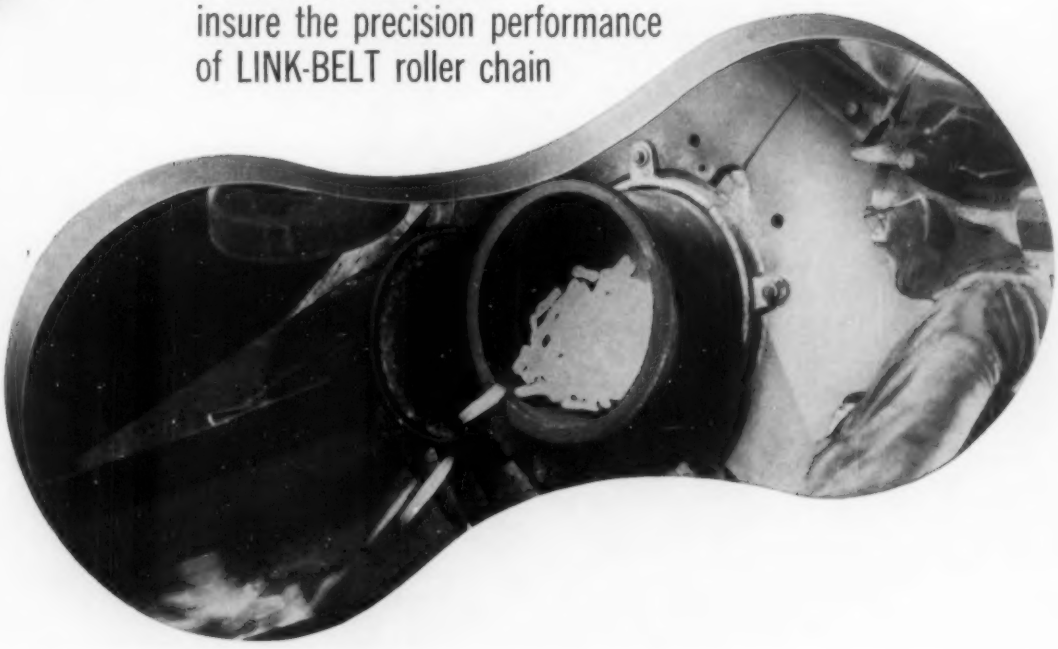


Here's another of the invisible extras that insure the precision performance of LINK-BELT roller chain

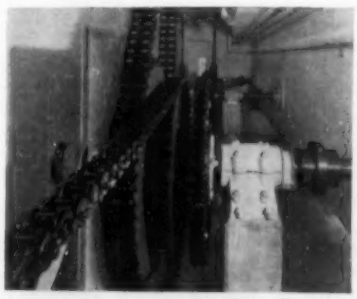


Painstaking precision of heat-treat control gives you

uniform strength in every link

To produce roller chain of utmost uniformity, Link-Belt maintains exacting control of all heat-treating processes. With equipment and instrumentation exactly tailored to the need, all processes are carefully adjusted to suit the characteristics of each heat and analysis of steel. Result: roller chain of uniform strength *well above accepted standards*. Chain that absorbs shock loads, delivers full power under continuous heavy going.

Precise heat-treat control is one of many *invisible extras* that contribute to the greater strength and endurance of Link-Belt roller chain. Others include prestressing, pitch-hole preparation, shot-peening. These features—plus painstaking precision and inspection in every step of manufacture—assure you of chain that can easily cope with today's heavy loads and high speeds.



Single and double strand Link-Belt roller chains combine to provide dependable, positive power transmission at this installation.

For engineering assistance in applying industry's preferred roller chain, contact your nearest Link-Belt office. See CHAINS in the yellow pages of your phone directory. Ask for Book 2657.

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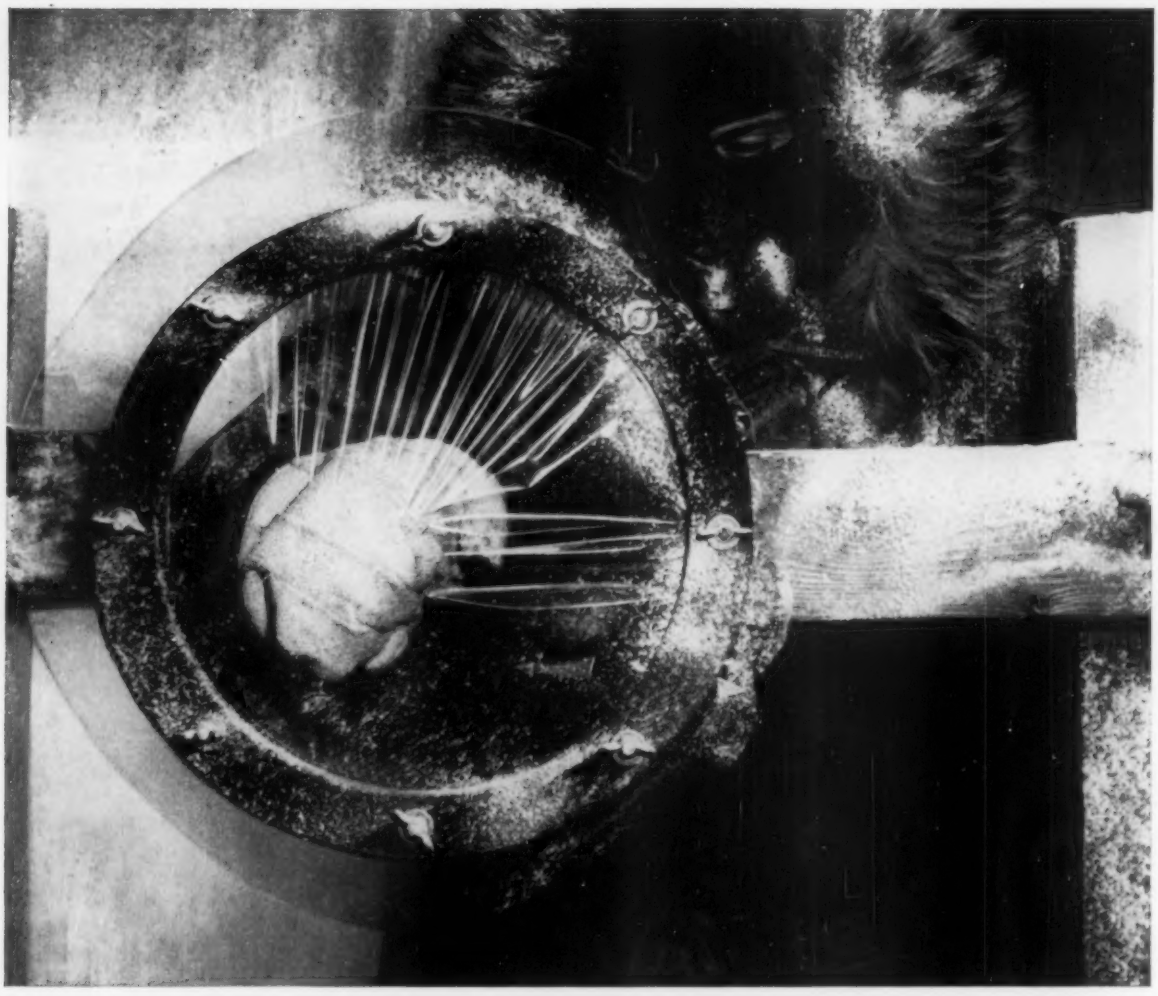
LINK-BELT

ROLLER CHAINS AND SPROCKETS



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FROM WASHINGTON . . .

Navy ditches designer of giant radiotelescope

The Navy is changing design engineers for its big radiotelescope at Sugar Grove, W Va. The project has come under criticism recently because design problems have already caused a 2-year delay in completing the big supersecret communication facility.

Navy has dropped the original architectural and engineering firm (Grad, Urbahn and Seeley of New York) and is negotiating with Ammann and Whitney to complete the engineering design of the project. Navy terms the parting as by "mutual agreement." It settled a lump sum contractual fee of some $5.8 million with the firm for $5.2 million.

Unofficial reports, however, have it that the Navy wanted to make too many design changes in the structure without increasing the designer's contract. The firm had completed nearly 90% of the design work before the parting occurred.

Design changes being made include substitution of high-strength steel to cut weight—also, taking control elements off the structure and mounting them in movable ground-installations.

Advocates say sea-launched satellites best

Enthusiasm for the launching of satellites from the ocean is picking up. Unofficial reports are that Navy will ask Congress to build a specially outfitted ship for such use in its 1962 budget that goes to Congress in January.

Advocates of the plan argue that it will not only be safer and cheaper than using land-launching sites, but would allow launchings to be made at any latitude desired. Primarily, equatorial launchings are needed for the satellite systems that require the so-called stationary satellites. These must be placed in orbits in line with the equator, moving at the same speed as the earth. In this position, the satellites remain in the same relative position with the earth.

Pentagon easing up on contractor rights to technical data

The Dept of Defense may change its contract requirements on proprietary information. Sometimes known as the "technical data" provision in defense contracts, the Pentagon is considering a proposal allowing companies to keep to themselves technical data developed at their own expense, but acquire all other data on an unlimited right basis.

Right now, when individual contracts are written, both the military and the contractor must make detailed lists of technical data and the degree of proprietary protection to be afforded. Under the new plan, this contract-by-contract approach would be junked in favor of the blanket ruling on the issue.

Where companies are to furnish components that have already been developed and sold or offered for sale, their proprietary rights will be protected.

Polaris missile outgrows its original carriers

The Navy's first five Polaris submarines will have to be refitted before they can fire the 1500-mi and 2500-mi Polaris missiles now under development. The reason is that the follow-on missiles are some 30 in. longer than the 1200-mi A-1 Polaris missile to be carried by the first five submarines.

Navy has already test-fired the first 1500-mi Polaris, dubbed the A-2-X. A second firing is slated for early in December. The missile is scheduled to be operational by early 1962. And the 2500-mi version of the Polaris, the A-3 series, will be ready within the next two to three years.

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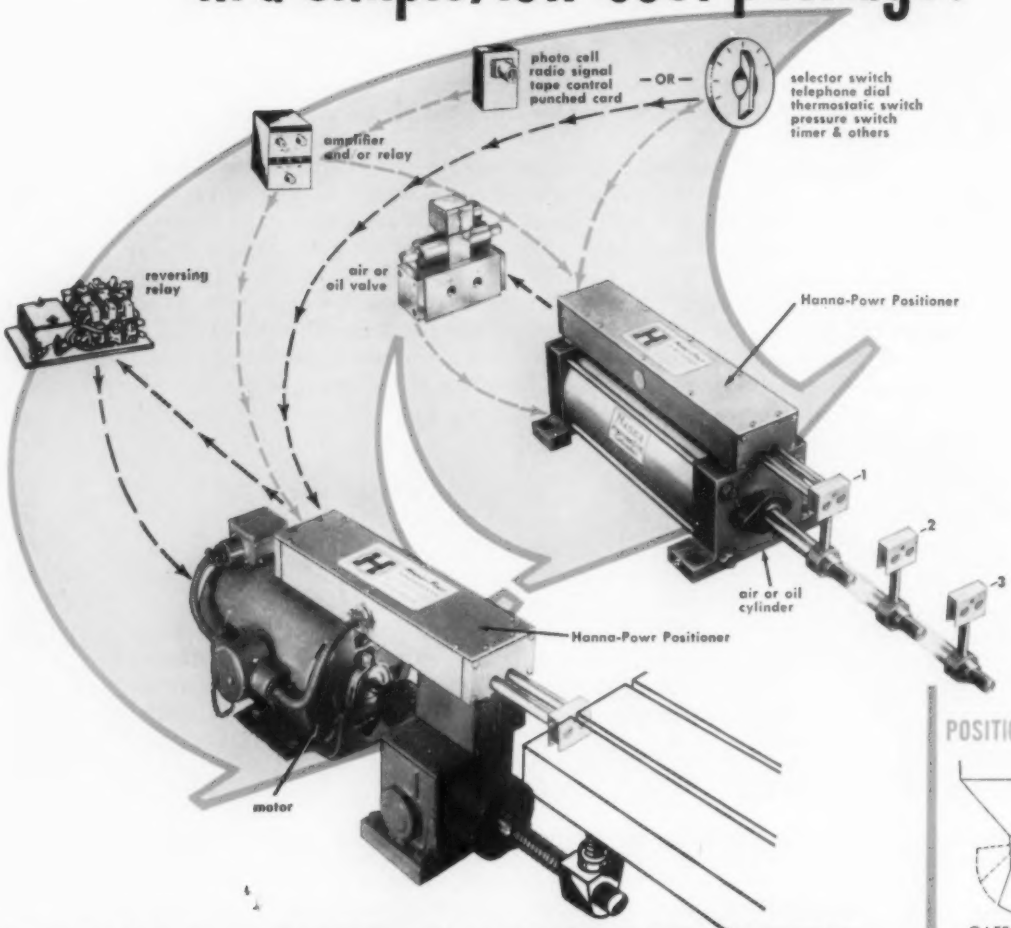

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THE NEW HANNA-POWR POSITIONER is a simplified, low-cost servo-mechanism used with air or hydraulic cylinders, electro-mechanical or other power drives to responsively achieve predetermined positions. The POSITIONER will also feed a signal to a read-out station to indicate the position point. Controls, such as selector switches, timers, thermostatic switches and others, feed signals to the POSITIONER for station selection—as many as 14 per foot of stroke. Infinite variations in positions are possible by simple movement of the adjustable limit switches. Stroke lengths may vary from a few inches to several feet to suit each application.

HANNA-POWR POSITIONERS save the time of designing special controls and cams, offer convenience of installation with one simple mounting for a group of controls, and cut maintenance costs by protecting all controls in a sturdy, dust-tight housing.

Your individual problems will suggest many uses for the HANNA-POWR POSITIONER. For more detailed information call your nearby Hanna Representative, (See "Cylinders" in the yellow pages), or write us for Catalog 500.

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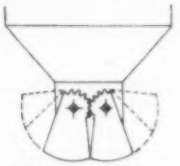
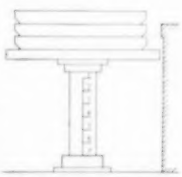


GATE POSITIONING



MULTIPLE POSITIONING OF LOADS

INDEXING

60 Years' Experience In Building the Finest Cylinders, Valves and Other Hydraulic and Pneumatic Equipment

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THE ENGINEERING WEEK

Italian Tool Design Swings to Automatic Controls and Standardization

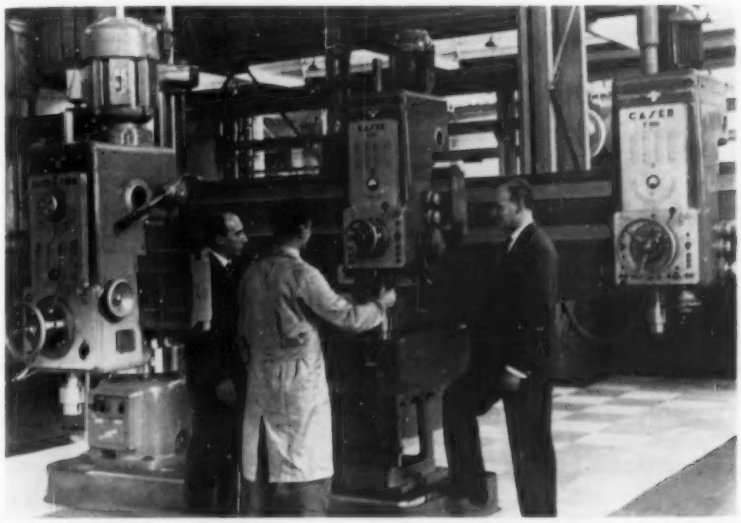
MILAN—The second edition of Italy's International Machine Tool Show (BIMU) this year produced a trend toward equipment with more flexibility and speed than that shown two years ago. These two improvements have been achieved by building-in more automatic cycles. Especially prevalent were automatic loading, speed- and feed-preselection servocontrols; positioning drums; and electromagnetic or electrohydraulic clutches.

A trend toward standardization was also in evidence. The pacesetters included some of Italy's largest toolmakers—Minganti of Bologna, Maxnovo of Novara, and Morando of Turin. Maxnovo exhibited a series of lathes having standardized interchangeable-unit construction. Morando showed a line of automatic screw-cutting lathes with interchangeable heads mounted on standard bases.

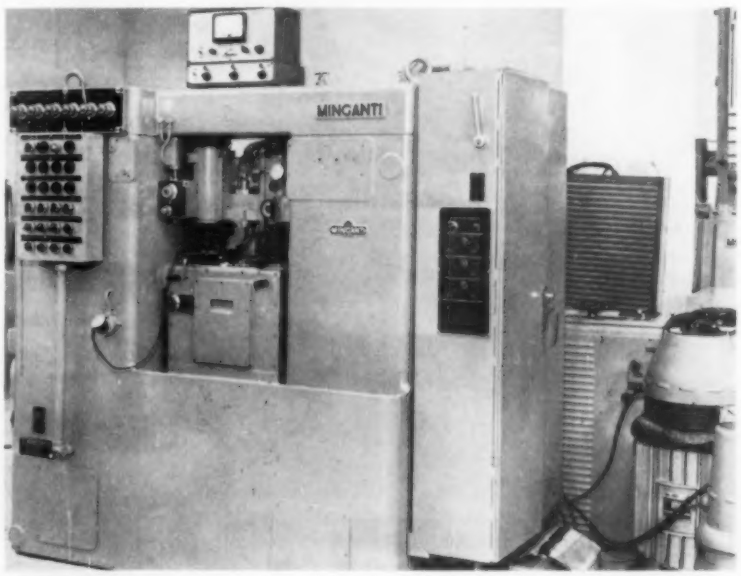
Three of Italy's largest makers of metalforming equipment—Mariani of Seregno, Galbadini of Varese, Ficep of Milan—introduced some new planing devices for metalworking.

In contrast to the first BIMU show, where only one numerical-control system was in evidence, this year's exhibition included a variety of punched-tape and punched-card systems. Among them:

- "Telephotomation," a rotating punched-card system developed by Maxnovo that can set and control work cycles for most types of machine tools. Each card represents a cycle for a different part. Cards are read by photoelectric cells.
- An electronic numerical programer with a coordinated measuring and positioning system installed on a boring machine by San Rocco of Monza. Dials set the program for each boring operation.
- A punched-tape controlled positioner on a turret drill for table positioning. It was shown by Caser of Pavia.
- An electrohydraulic copying lathe with six automatic working cycles, by Saimp of Padua. Cycles are controlled electronically by pushbutton; copying device and tailstock are controlled hydraulically. Saimp also showed a vertical milling machine with a fully automatic work cycle programed on an electronic plug-in panel. Centralized feed preselection and spindle-



TURRET DRILL with punched-tape control for table positioning was shown by Caser of Pavia.



AUTOMATIC HIGH-SPEED INTERNAL GRINDER by Minganti of Bologna will finish 0.04 to 0.24-in. holes with tolerances of 0.000,04 in. Spindle grinds ring bearings at 150,000 rpm. Because of automatic loading and unloading, and electronically controlled measuring equipment, the machine can be used for in-line transfer. Working cycle takes 26 sec.

speed-selection controls reduced setup time between jobs. Work cycle of 30 operations take 7 min.

The machine-tool industry here has spawned a related industry—the design and production of built-in automatic inspection devices for gaging and measuring. Marposs of Bologna, the only vendor of such equipment in the last show, was this year joined by Riv of Turin and Nova of Novara.

Marposs manufactures a wide range of automatic inspection equipment that can be mounted on grinding machines, on workbenches, or in inspection rooms to check mass- or batch-production. This equipment uses a "finger lock" to check surfaces and correct irregularities.

Fingers come in a number of shapes covering various operations of the machine—checking internal and outside diameters, internal grooves, outside surface or thickness and measuring keyed pieces. The fingers are applied to a single- or double-contact measuring head. The measuring head passes a signal to an electronic circuit which amplifies it so that measurement can be scaled.

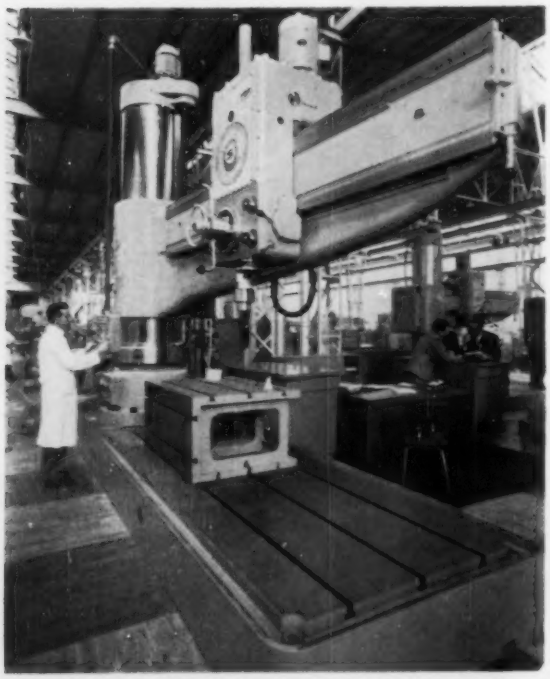
Test equipment shown by Marposs included precision comparators for internal, external and centerless grinding machines, measurement and control devices for surface grinding, duel-control comparators for selective comparative machining, apparatus for selective assembly, precision comparators for bench use, production-series checking devices, and multidimensional checkers.

Riv, manufacturing under license from Moore Products Co of the US, showed a line of comparators, multiple gaging and sorting equipment.

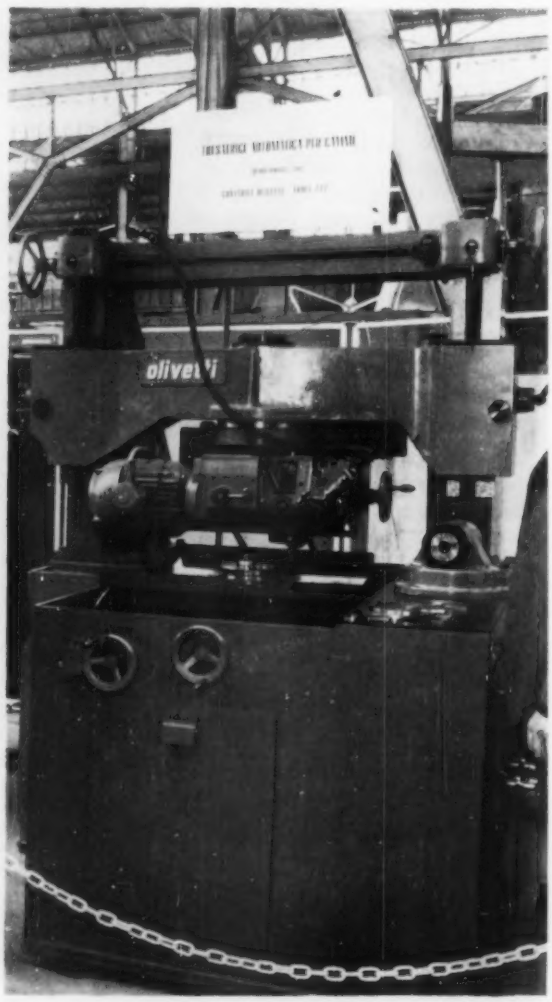
Nova featured an electronic sizing device for its internal grinding machines that directly sized work pieces. The system allowed tolerances as close as 0.000,16 in. It included a sizing head, an electronic unit with feeding amplification and control, and a diamond-tipped feeler.

On the Nova device, automatic switching from fast-traverse to rough-grinding feed of the grinding wheelhead is electronically triggered when grinding wheel contacts the workpiece. Other phases, such as cessation of rough or finish grinding, wheel truing, or return of wheelhead to extreme position, are controlled by the sizing head through its feeler, which is in permanent contact with the workpiece.

Conventional relays were widely replaced by static controls. Among man-



RADIAL DRILL (above) with electrohydraulic control was displayed by SASS of Turin. This was one of the largest machines at the Milan show.



CAM-MILLING MACHINE with punched-tape control was shown at the Olivetti booth. Various stages of its working cycle are calculated by computer and transferred to a punched tape. Electronic devices for controlling the tool holder include a punched-tape photoelectric reader, a punched-tape data-processing device, an analog numerical converter, an interpolating device and a precision servomechanism. The machine will cut cams up to a radius of 11.8 in. with an accuracy of 0.0007 in.

ufacturers of such equipment are Ercole Marelli of Milan, under license with Westinghouse; Pellizzari of Milan; Philips Italiana; Richardson Allen Italiana; Brown Boveri; Cea-Perego of Milan, and Riv of Turin. Static controls were widely used on grinders, plane-milling machines, boring machines and lathes.

Special computers for machine operations were again absent, but firms like Olivetti and Fiat are believed to have designed their own and put them into operation.

Equipment was displayed by 500 exhibitors—about 15% of them foreign. The fair attracted 42,589 visitors and produced $10 million worth of business.

—Gene DiRaimondo, Milan Bureau

Bouncing Radio Waves Give Radar Longer Range

Moscow—The Russian answer to the US Samos spy satellite may be the "Kabanov Effect" discovered by Nikolai Kabanov. According to the Russian scientist, powerful radio waves can team up with radar to picture areas thousands of miles away.

Kabanov has established that radio waves, when reflected from the ionosphere, are partially scattered when they return to the earth's surface. But certain portions of the scattered energy eventually return to the radiation point.

Thus, he explains, any area of the earth's surface can be observed on a radar screen by sending a powerful radio beam in the desired direction. The beam bounces between the ionosphere and the earth, finally reaching the area to be observed. Some of the waves return along the initial trajectory to the beam source. An image of the desired area is received and can be viewed on a radar screen. One drawback so far: signals from the intermediate bounce points are superimposed on the desired image.

Initial studies, Kabanov believes, will help in selecting the most favorable frequencies for long-distance radio communications, for observation and exploration of the ionosphere, and should improve radio communication by enabling low-power stations to transmit with simpler aerials and less interference.

—Ernest Conine, Moscow Bureau

Tractor Swims—and Climbs Too

On this amphibious Wagner tractor, each of the wheels is equipped with special Goodyear tires and is mounted on a leg which can be vertically orbited a full 360°. Special wheels permit vehicle to climb up banks 7 ft high, traverse streams and cruise in deep water—thanks to a propeller in the rear. A longitudinal hinge, connecting both ends of the 2-part chassis, enables the "Go-Devil" to turn.

British Reject Mass Production as Cure for Machine-tool Woes

London—A subcommittee of Britain's Machine Tool Advisory Council has rejected the conclusions of last year's Melman report, which urged more mass production and greater standardization of Europe's machine tool industry. The report, prepared by Seymour Melman, professor of industrial engineering at Columbia Univ, for the European Productivity Agency, warned that the Soviets are far ahead of Europe in application of mass-production techniques to the tool industries.

But the subcommittee, composed of manufacturers, trade unionists and government officials, believes there are ways other than European standardization to meet the Soviet threat. The group urgently appeals to Britain's toolmakers to step up their research. And it calls on British industry to aim for greater standardization—within limits.

The subcommittee points out that standardization on the scale proposed by Melman would require a degree of regimentation and control unacceptable to Western countries. The group also observes that if design is held to extreme standardization, the machine-tool industry will not be able to provide its customers with the high-performance, specialized equipment they need. At present, they said, Britain is losing markets to US, Swiss and West German manufacturers, who offer highly specialized machine tools to individual specifications.

Soviet competition, the subcommittee acknowledges, is a threat to British exports, particularly simple machine tools. This competition, it predicts, will intensify in trade with less industrialized countries. But for more advanced standard and special machine tools, UK manufacturers are expected to be able to hold their own in the world markets if their development effort is adequate.

The subcommittee report warns

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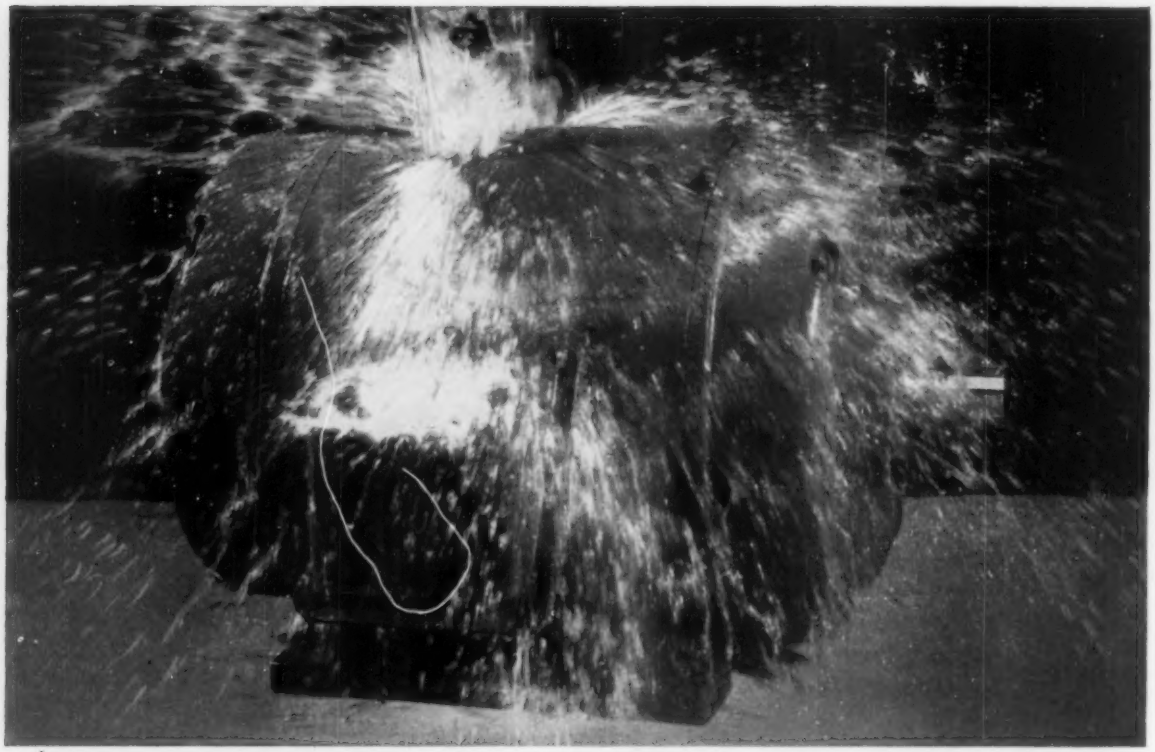

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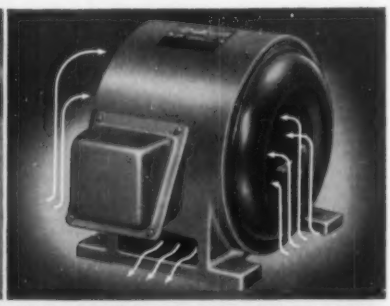

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USE: These AlSiMag ceramics have a high volume resistivity at elevated temperatures. Excellent insulators for such applications as metal sheathed thermocouples, heaters, range units, metal sheathed cable, etc.

METHOD: The ceramics are usually supplied in short length, multiple hole, tubing. The thermocouple or heater wires or rods are inserted in the holes in the ceramic and this assembly is inserted in the metal sheath and swaged. Swaging shrinks the tube, crushes the ceramic which thus forms an accurately positioned, densely packed uniform insulation.

MATERIALS: AlSiMag 689 magnesia, high purity, high Te value. **AlSiMag 714** magnesia, extremely high purity, electrically fused. Particularly desirable for atomic energy applications. Meets purity requirements of AEC Spec. AEC-SR-101 (ORD) and KAPL Spec. O-KPM7-1. (Technical Data Sheets available on request.) **AlSiMag 730**, alumina oxide, extremely high purity.

SHAPES: These AlSiMag crushable ceramics can be made to individual specifications. Multiple hole tubing is most frequently used, normally in lengths of .1" to 4". Dimensional and technical data sheets on request. Send blue print or sketch and performance requirements where special designs are needed.

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All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

continued from page 17

that Britain may have to rely more heavily on machine-tool imports and that exports may fall. To offset this threat, it makes several recommendations:

- Expenditures on R & D should be raised to 10% of turnover—about $22.4 million annually by the end of 1964. Current research is about $8.4 million.
- The number of qualified persons engaged in research should be raised from the present 120 to 250 or 300 by 1964. The new engineers could be attracted from other industries by instituting company training programs.
- Industry should aim toward greater standardization in location of tooling and ancillary equipment, and adopt standards for modular units recently adopted by the US automobile industry.
- Electronic control for machine tools should be developed.
- Surveys of future demand trends and age of machines currently operated in the UK should be undertaken.

Prof Melman Replies

NEW YORK—Prof. Melman, in this city, has expressed disappointment at the conclusions of the British group. He says the British have, in effect, ruled out further inquiry into manufacturing methods. He considers this a grave error of judgment. The British would be wiser, he says, to consider what manufacturing methods are available and which of these methods would produce optimum results for them. But their report suggests that no further research is needed.

European firms, he says, have explored opportunities for advancing their financial and market positions. But they have not explored opportunities for technological advances in manufacturing methods. ■

This Contract Requires Flaws in Castings

NEW YORK—For years, consumers and foundrymen have had precise radiographic standards of acceptance to guide the inspection of steel castings ¾ in. and thicker. Now, reference radiographs are being made to extend these standards to castings that are less than ¾ in. thick.

American Brake Shoe Co is producing sets of radiographs for Naval Ordnance Laboratory to show incisions, cold-shuts, shrinkages, cracks, gas holes, hot tears and misruns in 4130, 4140, 4330 or 4340, 347, 410 or 430, and 17-4 PH alloys. The government contract provides for manufacture of defective castings with walls ranging from 0.13 to 0.75 in. Castings will measure 6 in. wide by 8 in. long.

To make the flaws, the ABS Research Center at Mahwah, NJ, casts plates with and without tapers to produce varying degrees of soundness. Risers may also be varied in size or eliminated. Chills are used in some instances; in other cases, various appendages are attached to produce hotspots, which, in turn, generate changing conditions of internal shrinkage. Mold and metal temperature are additional variables.

When the job is completed and the reference manual published, designers, engineers, producers and consumers will have radiographic-inspection guides that, for the first time, will allow standard checks on section integrity. Also, the guides may provide a point of departure to improving the quality of light-steel castings. ■

PATTERN IS DESIGNED to produce a "perfect flaw" in a test casting. Engineers at the American Brake Shoe Research Center then compare defects of earlier radiographs with this pattern (photo, left), and make necessary design changes to produce a given defect—here, shrinkage—in the next series of castings. Shrinkage is controlled by the size, shape and location of the silver-coated wooden disks (foreground) and by the location of risers on the mold itself. Darkroom inspection (photo, right) shows flaw produced in test casting.

Registration by Mail Brings Better Engineering Education

KANSAS CITY, MO.—On the basis of three years' experience, the Univ of Nebraska is confident that its "registration-by-mail" experiment is fulfilling its intended function—to increase the percentage of those who get their engineering degrees. Under the plan, a student may choose his courses before going off to college. This is done on the basis of recommendations from the university and advice from his highschool guidance counselors and parents.

The program, as described by Prof J. S. Blackman, Dean of the College of Engineering and Architecture before the MAECON (Mid-America Electronics Conference) here, was started because university officials felt that the faculty often cannot provide adequate student guidance under pressure of registering 2200 freshmen the first week of school. Students who register by mail usually take a preregistration exam during the late spring. This exam, coupled with the students' performance in highschool and in college board exams, is used by the Nebraska faculty to make up a checklist of recommended courses. The student then works out his freshman program at home and mails it to the university.

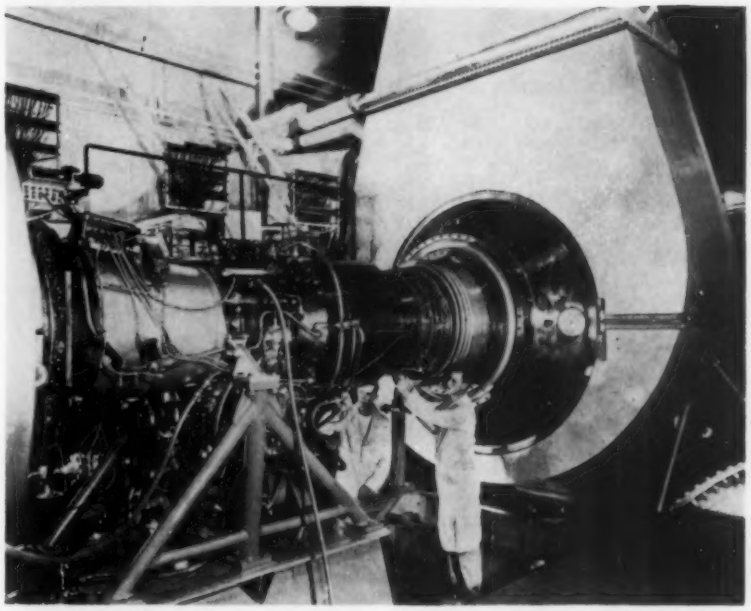
MORE TIME FOR STUDENTS

Prof Blackman said that the mail registration program gives new students time to chose their programs thoughtfully on the basis of scholastic strengths and weaknesses. With the job of registering out of the way, the student is then free to discuss long-range plans with his advisor during the first week at school. This year about 1400 registered in advance, compared with 400 in 1958.

Attrition rates for engineers over the nation as a whole have been climbing, Prof Blackman warned. In 1954-55 about 62% of those who had entered engineering school 4 years earlier got their diplomas. By 1958-59, the ratio fell to 47%.

The old admonition to entering freshmen engineers; "Take a look at the man on each side of you—he won't be here when you graduate," is disturbingly close to fact, Prof Blackman said. ■

Aircraft jet engine to pump natural gas



A Pratt & Whitney J-57 aircraft engine has been converted to power a Cooper-Bessemer RT-248 natural-gas turbine. The engine supplies 10,500 hp to turn this specially designed turbine, which features the "chimney" exhaust at right. The unit pumps about 600 million cu ft of natural gas a day through the recently installed Columbia Gas Co pipeline, which runs from Rayne, La to Ashland, Ky. It weighs 34,000 lb, about 1/6 the weight of a conventional gas-turbine unit and is the first of a family of jet-powered gas turbines to be rated from 350 hp to 15,000 hp. They are expected to find application in the natural-gas, petroleum and petrochemical industries; in power-generating and in the maritime area.

German Machine-tool Industry Swamped With Orders

BONN—German machinery production soared to $2636 million during the first 6 months of 1960—a gain of 18.4% over the corresponding period last year. The increased demand for machines is attributed to an economic boom and an acute labor shortage, which together have stimulated practically all German industries to invest in more equipment.

Exports of machinery also rose. In the first half of 1960 they reached $1024 million—a 15.9% gain over the same period in 1959. Thus Germany still ranks second, after the US, in machinery exports, and accounts for 16% of the world total.

Despite production gains, new orders are outstripping plant production capacity. Orders rose 41.2% during the first 6 months of 1960, even though prices were rising 5%. Delivery time for machinery is steadily increasing.

Some of this pent-up demand is being relieved by imports, though they are still relatively small. Imports for the Jan-June period this year amounted to $230 million, a 41.2% gain over last year. ■

Soviets Release Patent Data

ZURICH—The USSR has given permission for the export of its biweekly patent journal, which contains approximately 10,000 patents per year, all described in detail. Further information can be obtained from the following institutions: (1) Omelin-Institut, Varrentrappstrasse 42, Frankfurt-am-Main, W Germany; (2) Deutsches Patentamt, Museuminsel 1, Munich, W Germany; (3) Radaktion des Chemischen Zentralblattes, Moorenstrasse 39, Berlin W S, W Germany; and (4) The International Patent Institute, The Hague, Holland, which has a collection of patents from the USSR and satellite nations. ■

DOW

NEWS ABOUT PRODUCT DESIGN AND MATERIALS

Win the housewife's approval . . . and products designed for the home score success in the marketplace. By helping designers create colorful, durable products that are effortless to care for, easy to use . . . modern plastics assist in gaining the all-important nod of approval from the lady of the house. In these new products, for example . . .

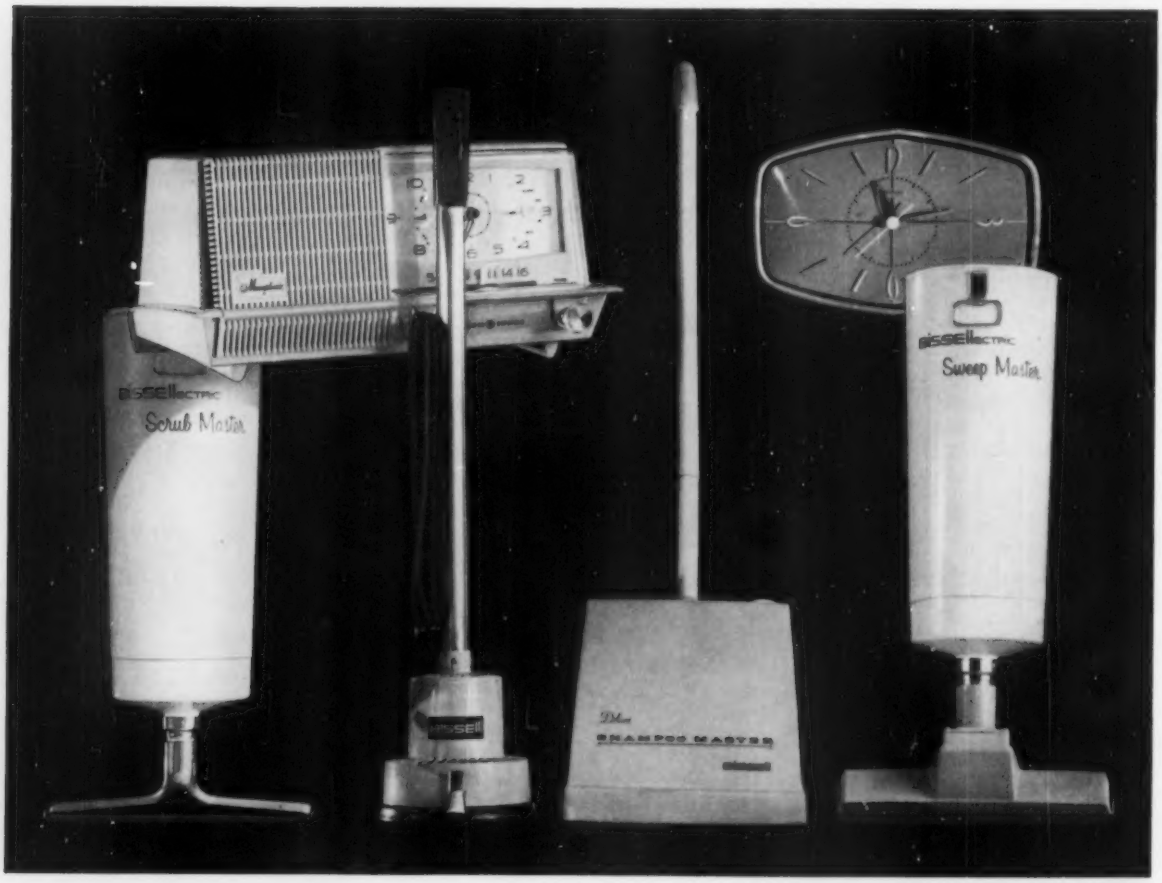
TODAY'S PLASTICS STAR IN NEW HOUSEWARE DESIGNS

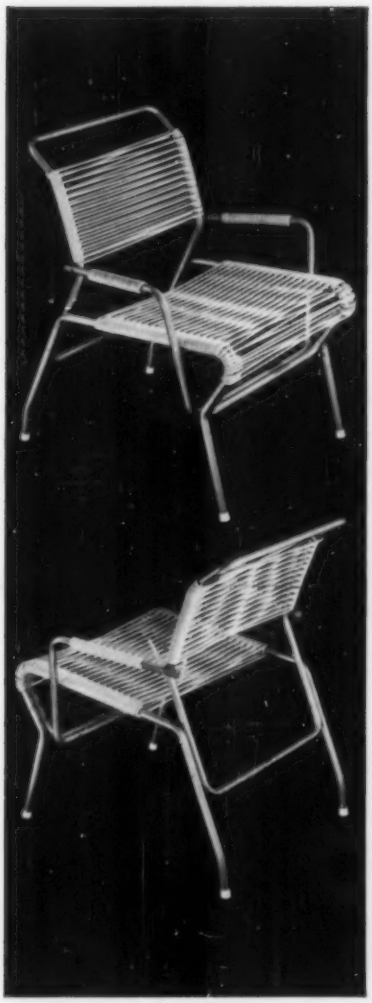
Whether the design is a new product or improvements for an old standard, Dow plastics are ready to help the designer. They provide a vast array of thermoplastics formulations—each with particular specialties. Take Styron®, for example . . .

The workhorse of modern plastics, Styron (Dow polystyrene) permits the designer complete color choice, with attractive surface finish assured. This material affords good flexural strength—provides excellent dielectric properties and low water absorption. Best of all, Styron is low in cost—molds, extrudes and thermo-forms easily—and is offered in 20 different formulations that spotlight particular design characteristics.

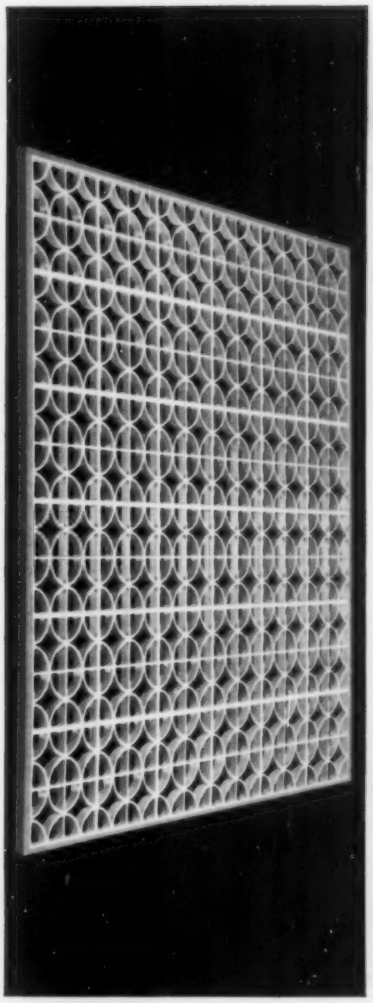
For example, in the new combination appliance designed both to vacuum rugs and scrub floors (illustrated below), tanks are made of Styron 475, developed specifically for high impact strength—three to five times greater than general purpose polystyrene materials. This formulation also provides the tank housing for the hard-working rug shampoo device.

Styron 369, a formulation that combines excellent heat resistance and good impact strength, makes a colorful case for the high-styled clock radio. And the wall clock takes advantage of other versatile features of Styron – the case is opaque while the protective dial cover is crystal clear.





For outdoor relaxation, handsome chairs are laced with cord of PVC, Dow polyvinyl chloride. Excellent aging characteristics, quick recovery from loads combine to assure durability and long-lasting comfort. In a wide range of colors, PVC materials clean easily.



For privacy on the patio, new wall divider grilles offer novel designs, maintain their good looks for years. Molded of Zerlon®, they are exceptionally strong, resist outdoor weathering . . . and stand up under blazing sun or freezing cold.

Cans open in a hurry with electricity turning the crank. And this can opener is a breeze to keep clean because the stand and housing are of Tyril®. Remarkably stain-resistant, this material withstands foods, oils, waxes, soaps . . . even solvents and many chemicals.

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CIRCLE 23 ON READER SERVICE CARD

POINTS OF VIEW

THE QUESTION: *How Good*

Launor F Carter, PhD
Director of research
System Development Corp
Santa Monica, Calif

The System Development Corporation of Santa Monica, Calif, is a nonprofit company formed to study the human factors in modern technology. In 1958, Dr Launor Carter of SDC approved a project proposal for research in the field of automated teaching, and he has remained active in these studies. He joined SDC in 1955 and is now director of research. Basic function of his office is the study of human factors, computer programing and operational design for large man-machine systems. Dr Carter's experience in human-factors work dates back to World War II days when he directed psychological research on the selection and training of navigators. He is an active psychologist; a fellow of both the American Psychological Assn and the American Assn for the Advancement of Science; chairman of the Psychology and Social Sciences Panel for the US Air Force's Scientific Advisory Board.

In the Oct 3 issue, PRODUCT ENGINEERING presented an engineering editor's evaluation of teaching machines. Now a research director, who is also a psychologist, warns that if these education aids are underdeveloped and oversold, the public—which will have to pay the bill—may reject them.

Although we frequently deplore the way social progress lags behind technology, we don't often do anything about it. In the area of education, we are especially conservative. The first formal education system relied, for transfer of knowledge from teacher to pupil, on the spoken word or guidance by example.

During the sixteenth century, books became a major tool in the process of formal education. Even now, they continue to be the major instrument used by educators. But while technology has improved and replaced tools in practically every other field of endeavor, the educator's basic tools have remained relatively unchanged, except for type faces and quality of paper. Here we have a paradox. Each succeeding year, technology is increasing the magnitude of knowledge we humans must absorb. Each succeeding year, new ways are being discovered to do all manner of things. Yet the very advancements in technology that are applying the pressures for vastly greater education are not being adequately used to satisfy this need.

Only within the past decade or so have we begun to recognize the changing educational situation and the means for dealing with it effectively. Lecture-type technology has lately begun to appear in a few classrooms in the form of closed-circuit television, tape recorders and motion-picture films. Even more recently, initial development of teaching machines has been taking place. Teaching machines differ from the lecture-type devices in that they present to the student small units of the curriculum in progressive steps. The student is immediately reinforced after each unit has been presented by having his progress evaluated through questions and answers. Usually, but not always, correctness of response is the criterion for advancement to the next unit.

In spite of—or perhaps more correctly because of—my

Are Teaching Machines?

interest in seeing technology used more effectively in education, I am deeply disturbed by some of the trends and overenthusiasm relating to teaching machines. I cannot but believe that some teaching-machine systems are being marketed prematurely. I fear that future acceptance of teaching machines will be severely retarded if present inadequacies disappoint the expectations of the teaching profession.

Here at SDC we are working on a computerized teaching machine that will evaluate the progress of each student and program his course of study accordingly. This is a big step forward in the state of the art, but we feel we are still far short of having a practical system for use in public schools. We look upon our system as a laboratory from which we hope to develop practical and satisfactory educational tools. The profession hopes to develop a system that can be used as a yardstick for evaluating teaching machines.

Developing a teaching machine

To develop a teaching machine, two fundamental considerations must be recognized. First, of course, is the physical hardware. This may be anything from a simple book utilizing overlays to a complex computerized system like SDC's. At least as important as hardware is the actual programing of teaching material to obtain the desired results. The most sophisticated machine in the world is of little value without properly programed learning material. My objections to many of the present-day teaching machines are based on considerations of hardware and of teaching programs. I feel that the hardware is inadequate because it is too clumsy and hard to manipulate for programing of instructional material. Those machines where program versatility has been increased have become so physically complicated that they are impractical from the point of maintenance and cost.

Programing is inadequate mainly because of a lack of experience in the field. Partly because of physical limitations and partly because of limited experience, most programing has to be leveled out and compromised for the average student rather than for students who differ in ability. At SDC, our general-purpose computer has been programed to evaluate the student's progress periodically and adjust to his individual needs. This is a step toward individual education, and it avoids throttling intellect through mass treatment.

What about tomorrow?

The future for teaching machines is bright and vast. They will adapt very well to any subjects that can be stated in positive terms. This includes mathematics, physics, grammar, and even the mechanical phases of many art forms such as learning to read music, fundamentals of pictorial composition, and basic structures for writing. They will not, however, be able to teach subjects that require emotional interpretation.

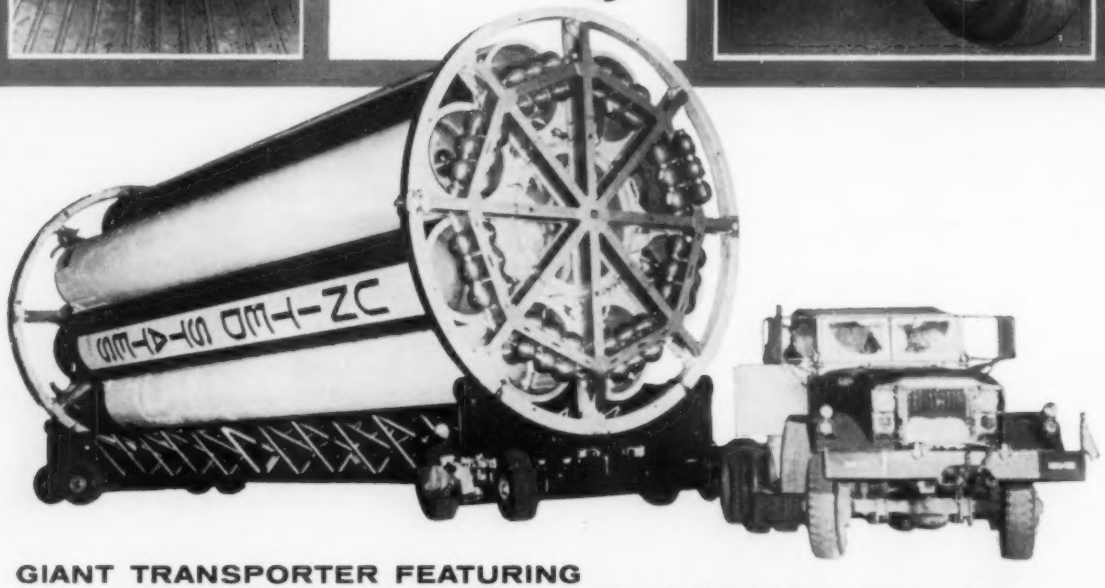
Even in well-defined subjects, the teaching machine cannot replace the human teacher. Machines cannot think and evaluate, except to programed standards. The student cannot ask a random question of the machine and get an understandable reply. The machine can reinterpret the subject matter only within the limits of the program. The teaching machine will become another and very valuable tool to the teacher . . . not a replacement. The machine will take over the routine and time-consuming duties of class drill, paper-correction and basic teaching while the human teacher devotes more time to the individual students.

The problem of human resistance

Developing the proper hardware and learning-programs will not take long; this is merely a matter of time and effort. But human resistance is another matter. Teachers, like other professionals, like to preserve their traditional ways of doing things. And a small, but vocal, group of parents can resist any change and constitute a far greater impediment than any technological problem. The taxpayer who reads only the initial costs of teaching machines and ignores their ultimate savings will apply pressures to keep machines from being adopted. If we add to these deterrents some unfavorable experiences with the prematurely marketed machines, otherwise rational people may turn against teaching machines.

Although I have a few misgivings about some of the things that are now being done in the field of teaching machines, I am, nevertheless, pleased with this growing interest. Within my own field of psychology, this interest is forcing a change of attitude toward experimenting with the teaching processes. In the past, we have busied ourselves with the study of learning procedures exhibited by rats, monkeys and other nonhuman subjects. Programing teaching machines is now forcing us to practical applications in human teaching with less emphasis on theoretical aspects.

Many issues have been raised about the relative merits of one teaching system over another. Many of these arguments are significant and probing, some are superfluous and shallow. Nevertheless, research and development must go on to help bridge the growing gap between the increasing knowledge to be imparted and the critical shortage of human teachers.



GIANT TRANSPORTER FEATURING
ACIPCO "WALKING BEAM ASSEMBLIES" WILL HELP...

Saturn's conquest of space

The moment draws near when America's Saturn rocket will thunder into space. But in the meantime, elaborate ground preparations are now taking place.

From the N.A.S.A. Marshall Space Flight Center in Huntsville, Alabama, via a circuitous land and water route to the launching site, the missile and its valuable cargo will be gently cradled on the huge transporter shown here. Acipco walking beam assemblies (upper left) are vital parts of this transporter.

These rugged assemblies are constructed of high strength alloy steel and comprise centrifugally spun and statically cast component parts . . . all produced at Acipco. Also, all precision machining and intricate fabrication work were done by skilled Acipco personnel.

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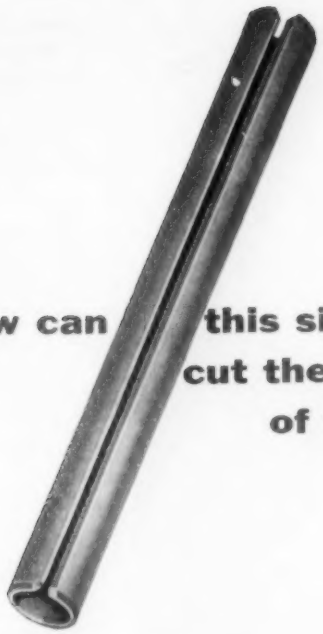

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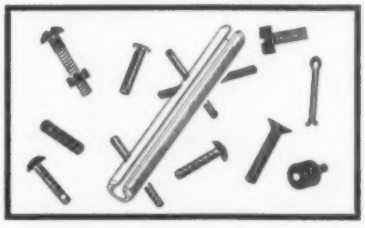

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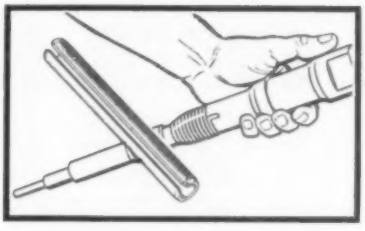

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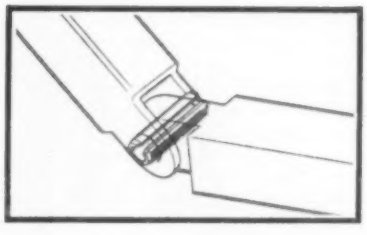

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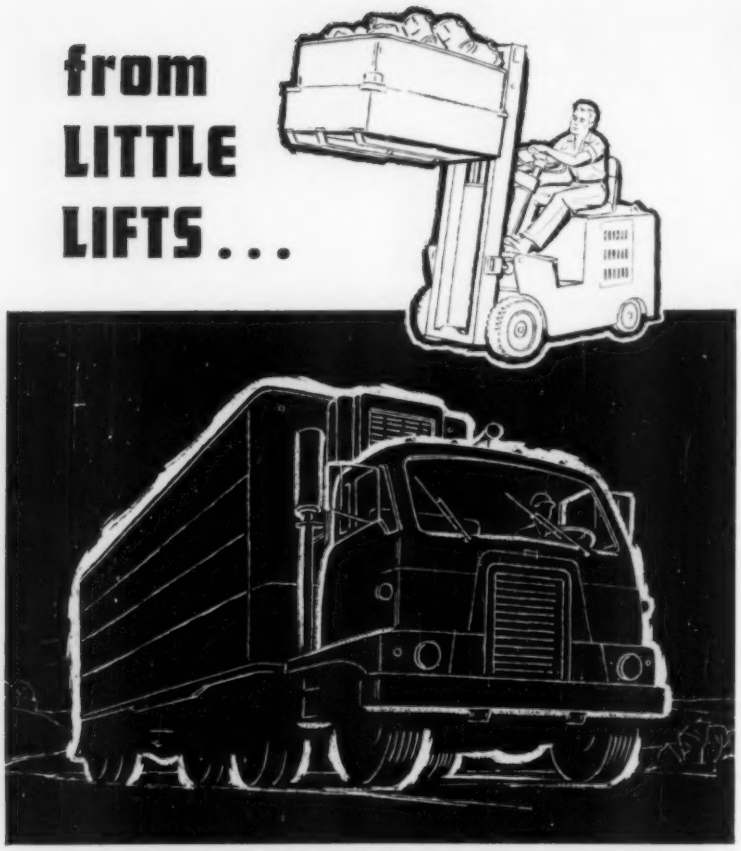

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READER TO EDITOR

Blinding Power of Statistics

To the Editor:

I read Mr Simberg's article, "Creativity Tests ARE Helpful" (Oct 17, p 73), fully prepared to accept the author's thesis. It seemed logical; and while the test questions themselves were a bit naive, you can hardly expect him to publish his best ones as samples.

But then I hit that 1% confidence level and realized that once again we were dealing with the blinding power of statistics. This analysis suffers from precisely the same sort of myopia that afflicts all statistics applied to man. Odds of 99 to 1 against a chance distribution of test scores is not at all the same thing as 99 out of 100 correct evaluations of creative ability. As a matter of fact, if you take a score of 2850 as the dividing line (halfway between the means of 2200 and 3500 for the low and high creative groups) ¼ of the men in the *low* group must have scored *above* 2850, and ¼ of the men in the *high* group must have scored *below* 2850.

This means that the test increased the odds from 50 out of 100 wrong evaluations to only 33 wrong evaluations. Would you want to be hired on the basis of so unreliable a test? Well then, what would be a fair test? I'd say let the test err 10% of the time. One out of 10 creative men would be called noncreative, one out of every 10 noncreative men would be misclassified as creative. Now the odds against a chance distribution of this kind make the confidence level a decimal point followed by more than a dozen zeros! I note that the test takes over 80 minutes. Frankly, I wonder whether that time might not be much better spent in interviews and in checking references. Both would increase the odds more than these tests seem to.

—Richard Myram
NYC

A Word to Wordsters

To the Editor:

I was surprised at Mr Gerlach's reaction (Oct 10, p 28) to my letter of July 25 dealing with the use of such words as "maintainability"; and, in particular, his reaction to my distaste for the word "winterization." Winterization is used in this case for the adaptation of standard equipment to low-temperature operation. The —65 F Mr Gerlach describes in his letter is not so severe. It occurs even in the charming little city of Fairbanks, Alaska.

In the past, I have had some familiarity with winterized equipment and have helped arrange for shipment of this type of material to the Hudson Bay littoral. During the course of this and similar operations I came to have a great respect for the best designers and makers of arctic equipment.

The English language is a beautiful and precise tool for the development and conveying of thought, and each writer has a duty to keep it sharp and pure. Elegance,

in English, dictates that the parts of compound words should be derived from a single language. This seems to apply with particular force to words derived from the Greek. Two correct word-unions are "kindergarten" and "windchill."

It is suggested that "frostproofing" or "chillproofing" or even a word derived from krios be used in place of winterization. Actually "proof" has a distant Norman French background, but it became naturalized at an early period. The word "frost" formerly had a wider meaning. Even today, at sea, we speak of "black frost"—the dangerous heavy ice that forms on fishing vessels from blown spindrift. All in all, I am for the word "frostproof."

—Alan Osbourne
Consulting naval architect and marine engineer
Cabin John, Md

Don't Forget Spur Gears

To the Editor:

Mr Rappaport has shown again how readily the compound planetary system with dual sun gear can be modified for ultrahigh gear ratio by using helical gears to provide compatible center distances (Oct 17, p 61).

It would seem worthy of mention that the same result can be obtained with spur gears by employing nonequal rolling-pressure angles in the two meshes; this has the decided advantage of not introducing superfluous axial loads.

—Edward A Brass
Norwalk, Conn

COMING EVENTS

DECEMBER

5-8 . . . . American Institute of Electrical Engineers, National Conference on Application of Electrical Insulation, Conrad Hilton Hotel, Chicago

13-15 . . . . Institute of Radio Engineers jointly with AIEE & ACM, Eastern Joint Computer Conference, Hotel New Yorker & Manhattan Center, NYC

26-31 . . . . American Association for the Advancement of Science, NYC

JANUARY

9-11 . . . . Institute of Radio Engineers jointly with AIEE, ASQC & EIA, 7th National Symposium on Reliability and Quality Control, Bellevue-Stratford Hotel, Philadelphia

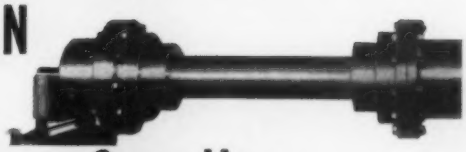
9-13 . . . . Society of Automotive Engineers, International Congress & Exposition, Cobb Hall, Detroit

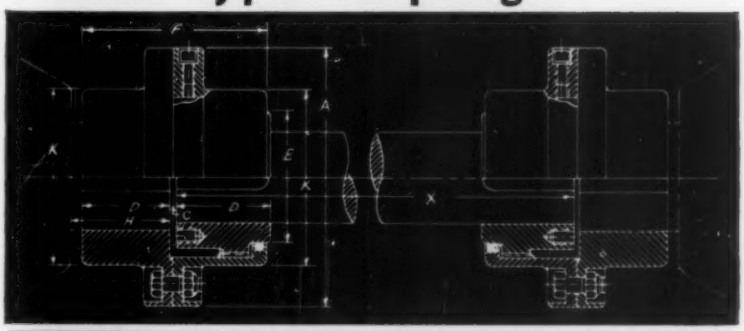
16-19 . . . . Instrument Society of America, Winter Conference & Exhibit, St. Louis.

29-Feb. 3 . . . . American Institute of Electrical Engineers, Winter General Conference, NYC

design facts....on

WALDRON Floating Shaft Type Coupling





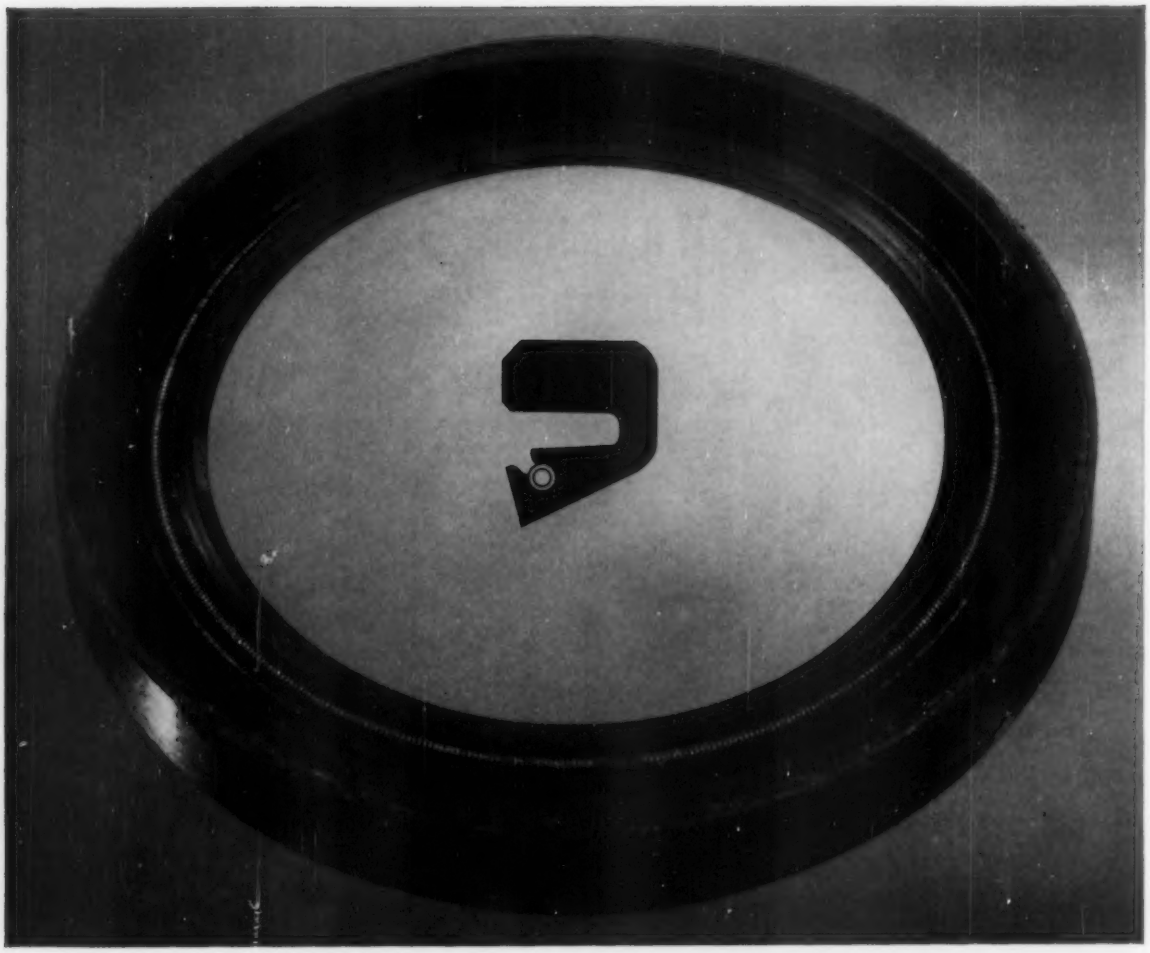
Size	Max. Over Bore Flex. Half	Max. Over Bore Rigid Half	H.P. Per 100 R.P.M.	Dimensions in Inches A	C	D	D1	E	F	H	K	X	Ship. Wt.* in Lbs.	Total Oil Req'd in Pts.	Size
1¼A	1⅛	1⅜	3½	4⅝	⅛	1½	1 11/32	2	2⅝	1½	2 11/16		22	1/10	1¼A
2A	2⅛	2½	12	6	⅛	2⅛	1 29/32	2⅝	4	2⅛	3 15/16		42	⅛	2A
2½A	2⅝	3	26	7	⅛	2 7/16	2 5/32	3⅛	4¼	2⅝	4 25/32		70	⅕	2½A
3A	3 5/16	3¼	50	8⅛	3/16	3 1/32	2 27/32	4¼	5⅛	3 5/16	5¼		120	¼	3A
3½A	3⅝	4¼	86	9 5/16	3/16	3 15/32	3 13/32	5	7	3⅝	6½		160	½	3½A
4A	4¼	4⅞	130	11	¼	4 1/16	3 15/16	5½	8 3/16	4¼	7 11/16		215	¾	4A
4½A	4⅝	5⅜	210	12½	¼	4¼	4 11/32	6½	9 5/16	4¼	8 21/32		350	1	4½A
5A	5½	6½	300	13⅜	5/16	5⅛	5	7½	10⅛	5¼	10⅛		460	1½	5A
5½A	6	7¼	410	15 5/16	5/16	6¼	5¾	8	11⅛	6	11⅛		650	2	5½A
6A	6⅝	8	550	16 5/16	5/16	6⅝	6⅛	8⅝	12⅛	6 1/16	12 5/16		820	2½	6A

*Weight of Floating Shaft not included.

The floating shaft arrangement meets the problems of remote drives and excessive misalignments. This arrangement consists of two rigid female hubs on the driving and driven machines with a male half of a standard coupling on each end of the floating shaft, that separates the connected machines. The length of the floating shaft is limited by the critical speed, since this arrangement requires no intermediate bearings. The hub arrangement can be reversed, that is, the rigid hubs can be installed on the floating shaft and the flexible halves on the driving and driven machines. This arrangement is optional, except that it is better practice to have the rigid hubs on the driving and driven machines in the event that it is necessary to run the machines independently.
Write for Catalog.

WALDRON Couplings

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
BOX 791, NEW BRUNSWICK, N. J.

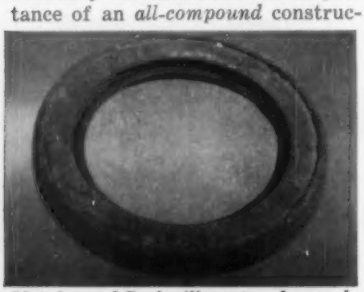


Tame corrosion with J-M Clipper® Seals!

Their all-compound construction

- **prevents rusting in the cavity**
- **provides better bearing protection**
- **simplifies removal and replacement**

The two pictures on this page dramatically demonstrate the importance of an *all-compound* construction where corrosives must be reckoned with. The Clipper Seal shown above has seen service in a severe application. Yet unlike seals of other than all-compound construction, it has come away unharmed and still fit for further service. *Nothing* in a Clipper Seal can rust, or corrode in the cavity, or cause pitting of bore surfaces. In the styles using a garter ring, even the spring is made of stainless steel!

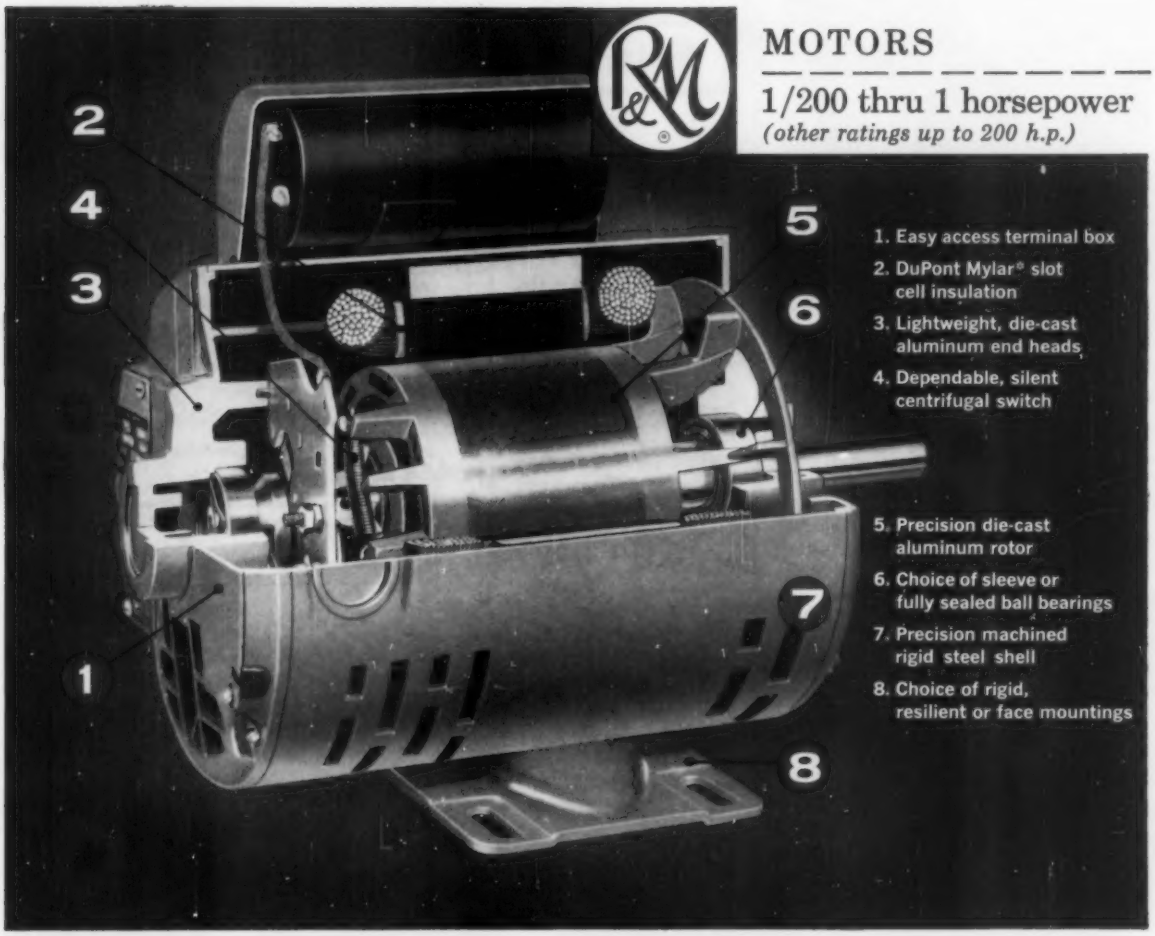


Metal-cased Seal will rust and corrode

A Clipper Seal consists of a soft, flexible lip and a tough, dense asbesto-compound heel, concentrically moulded into one unit. The heel effectively protects the bore from damage, and you'll never need to scrape or refinish the bore surfaces. Clipper Seals come away clean and easy . . . replacement is fast and requires no special tools or adhesives. And for quick, temporary replacement, Johns-Manville produces a special split seal.

Let your J-M Distributor help you select the *right* seal for your service conditions from the wide range of designs, compounds and durometer stocks available. Or for a copy of helpful book PK-71A, write to Johns-Manville, Box 14, New York 16, N.Y. Cable address: JOHNMANVIL. In Canada, write to Port Credit, Ont.

JOHNS-MANVILLE JM PRODUCTS


MOTORS
1/200 thru 1 horsepower
(other ratings up to 200 h.p.)
1. Easy access terminal box
2. DuPont Mylar® slot cell insulation
3. Lightweight, die-cast aluminum end heads
4. Dependable, silent centrifugal switch
5. Precision die-cast aluminum rotor
6. Choice of sleeve or fully sealed ball bearings
7. Precision machined rigid steel shell
8. Choice of rigid, resilient or face mountings

R & M Fractional Horsepower Motors are packed with *Competitive Advantages* for your product!

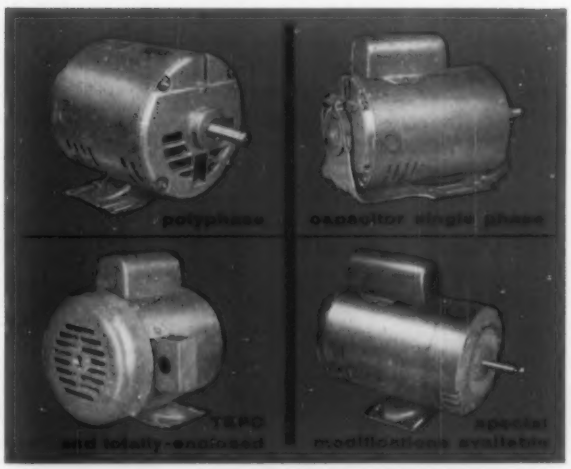
ROBBINS & MYERS "Model R" fractional HP motors, available in NEMA frames 56 and 48, are engineered and manufactured to give your product every possible competitive advantage so far as power is concerned. Each design detail results in superior performance and long trouble-free life, even under the severest operating conditions. They are smaller due to a more efficient ventilating system and lighter because of new applications of aluminum, steel and copper.

You have wider design versatility too, because they are available off-the-shelf in a broad choice of bearings, mountings, ratings, speeds and electrical characteristics.

These up-to-date design features, coupled with careful quality control at each manufacturing step, give you a modern motor you can rely on for all your powering needs. Also, if your needs indicate a custom designed motor Robbins & Myers welcomes the opportunity to discuss your quantity requirements.

Learn all about the many advantages R&M motors offer you by writing today for Bulletin 450-PRE.

*DuPont registered trademark



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

CIRCLE 31 ON READER SERVICE CARD

This KENNAMETAL* lined container grinds some of the hardest known materials to powder

Tungsten metals, silicon carbides, asbestos fibers, blast furnace slag, copper shot, alumina beads . . . are all conquered in this grinding vial used in a laboratory size mill.

Such materials pack, thereby preventing thorough grinding. At the same time, they peen out, smear and erode the surfaces of the usual mortar and pestle or ordinary ball mill. But the Spex Mixer Mill, using Kennametal Balls in a Kennametal-lined cylinder, can grind a lab size sample down to —300 mesh or finer in just 10 minutes. Grinding is uniform, with hardly a trace of contamination.

The hardness of Kennametal (up to 94.7 Rockwell A) makes the difference. Hardness is but one of the many exceptional properties of Kennametal. When you need a material with great rigidity, resistance to heat, corrosion, abrasion, erosion, and compression . . . chances are Kennametal may be the answer.

To help solve an immediate problem, or a future need . . . we'd like to send you Booklet B-111B, "Properties of Kennametal" and our new Booklet B-666, "Proven Uses of Kennametal and Kentanium."* Write Dept. PE, KENNAMETAL INC., Latrobe, Pennsylvania.

*Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium, and tantalum. Kentanium is the registered trademark for one of the series that has special advantages for applications requiring a lighter weight material or maximum resistance to temperature extremes. 33538

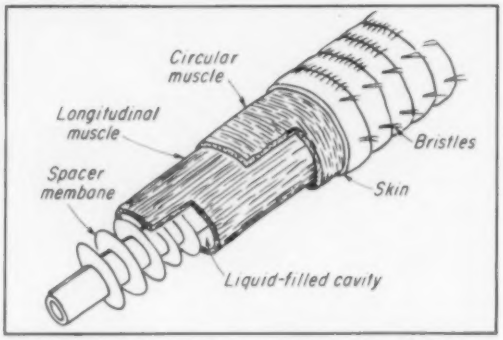
INDUSTRY AND KENNAMETAL ...Partners in Progress

FOR YOUR INFORMATION (personal)

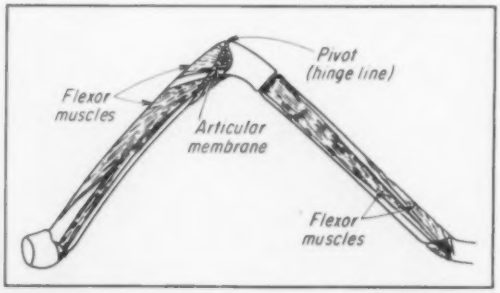
Nature has hydraulics engineers too

Looking for an efficient hydraulic system? Don't overlook the earthworms, and those web-spinning experts, the spiders. They have hydraulic locomotion systems that rate careful study, and the British have been doing just that.

The earthworm moves by stiffening and relaxing a muscular "envelope" which contains a series of liquid-filled cavities (see diagram). A constant volume of liquid is maintained in each cavity. When the longitudinal muscles in any region contract, the circular muscles relax and the region shortens and thickens. Relaxing the longitudinal muscles has the opposite effect. By combining these two actions, the earthworm inches forward.



EARTHWORM MOVES by lengthening and shortening fluid-filled cavities; uses bristles to grip soil.



SPIDER has flexor muscles but no extensors; uses fluid pressure to straighten leg.

The musculoskeletal system of the spider looks more conventional; but here, too, says D. A. Parry of Cambridge Univ, hydraulics plays an important role. Writing in the Imperial Chemical Industries publication *Endeavour*, he points out that fluid pressure as well as muscular action help the spider move. Blood pressure in this bug's hinge joints increases as the joint is extended, and there is a definite relationship between blood pressure and hinge-joint torque at different angles of extension. At rest, the pressure is about 5 cm Hg; but the spider increases it to about 40 cm in periods of great activity.

Safety on ice

Want to be a "Winter Winner"? National Safety Council will tell you how in two new booklets, based on actual road-safety tests of winter driving. The booklets chart the effect of temperature on braking distance, tell how much chains help, and provide checklists for prewinter tuneups. Single copies of the booklets, *Keep Rolling With Safety* and *Be a Winter Winner*, are free from NSC, 425 N Michingan Ave, Chicago 11.

It's element-ary

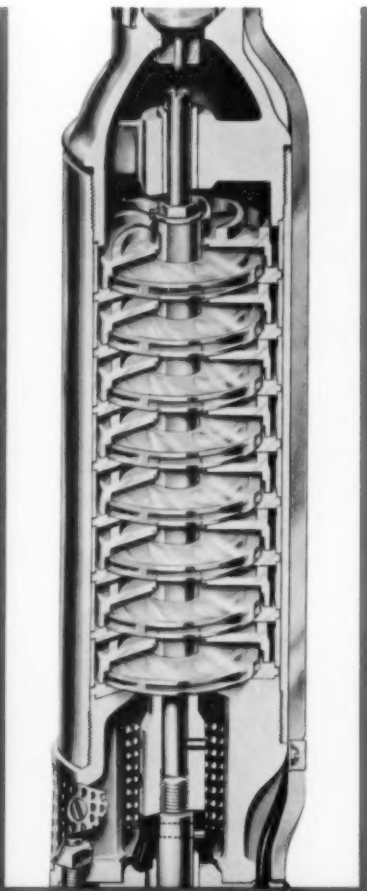
A card game of the chemical elements—complete with wall-size periodic table; a deck of cards packed with information on atomic weight, nuclear makeup, valence, and physical properties; and an informative handbook—is now available from Science Materials Center, 59 Park Ave South, New York 3. The game is played much like rummy, the object being to acquire cards that run consecutively in the periodic table, with isotope pairs counting extra. All the elements so far identified are represented. The price: $3.95. —ARG

CIRCLE 33 ON READER SERVICE CARD→

LEXAN®

POLYCARBONATE RESIN

HAS ALREADY SOLVED DESIGN PROBLEMS IN OVER 300 COMMERCIAL APPLICATIONS



LEXAN IMPELLERS stand up where others fail because of Lexan's toughness, low water absorption and resistance to heat and abrasion. Acid, iron and sulphur waters do not halt submersible pumps made by The F. E. Myers & Bro. Co., Ashland, Ohio. (Molded by Michigan Translyte Molded Plastics Div. of St. Regis Paper Co., Dexter, Mich.)

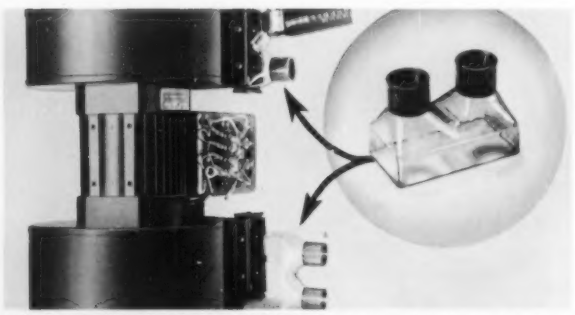
GENERAL ELECTRIC offers you more than 3 years experience in design and fabrication with this tough, rigid thermoplastic

Lexan's exceptional combination of properties includes:

- High impact strength
- Dimensional stability
- Heat resistance
- Good electrical properties
- Creep resistance under load
- Resistance to many chemicals
- Self extinguishing
- Transparent
- Colorable
- High gloss
- High strength at low temperatures
- Non-corrosive
- Oil and stain resistant
- Versatile fabrication

NOW TWO GENERAL ELECTRIC GIVE YOU LEXAN THERMOPLASTICS

HOUSINGS OF LEXAN thermoplastic protect riding lights on the trailing edges of Lockheed's F-104 Starfighter. The transparent resin withstands high friction caused by speeds of 1500 mph, thanks to its exceptional resistance to wear and heat. The material can take high-altitude cold. (Housings molded by Crescent Mold Engineering Corp., N. Hollywood, Calif.)



BLOWER COUPLINGS for radar unit are tough, flame-resistant . . . give smoother air flow than could formerly be obtained with brass fittings. Fabricated of LEXAN polycarbonate resin, they withstand cycling from −54°C to +54°C under humid conditions. They are inexpensively vacuum-formed, allowing considerable savings in machining costs. (Used by the Tracking and Acquisition Radar Equipment Section of General Electric Company, Syracuse, N. Y.)

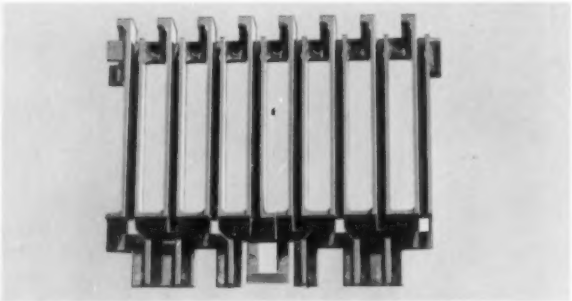
G. E. OPENS NEW LEXAN PLANT

Now, only G.E. offers two-plant flexibility in polycarbonates—a commercial plant and a semi-works plant for continued research and development in polycarbonate resins. The new plant, at Mount Vernon, Indiana, meets the increasing demand for LEXAN resins. The additional capacity, amounting to millions of pounds per year, makes General Electric the largest supplier of polycarbonate resins in the United States!

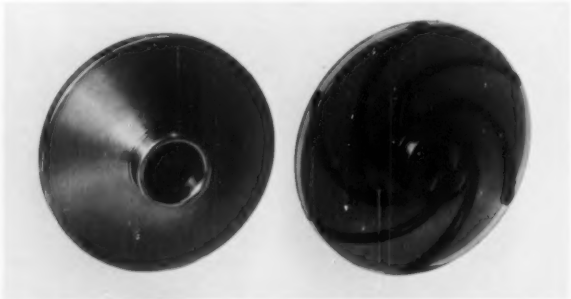
Pioneer in polycarbonates, G.E. has cooperated in the use of LEXAN resin in over 300 commercial applications. You can draw on this experience through G-E Technical Service. For a complete rundown on properties, uses, design considerations, molding and fabricating tips – send for LEXAN technical literature—the most complete literature on polycarbonates available! (*Coupon on page after next.*)

LEXAN —for designs that demand exceptional properties. If you want high strength and heat stability in a thermoplastic, use LEXAN polycarbonate resin. So tough is this material that it can actually be cold-formed and coined like a metal. It withstands over 12 foot-pounds per inch of notch—an impact strength attained by no other plastic. At the same time, LEXAN resin gives you a heat distortion point as high as 290°F! These properties are combined with outstanding dimensional stability, low water absorption, good electrical characteristics and other advantages.

LEXAN resin can be injection molded, extruded, vacuum formed, machined and bonded. It can be made into high-precision moldings, sheet, rod, tube, filament.

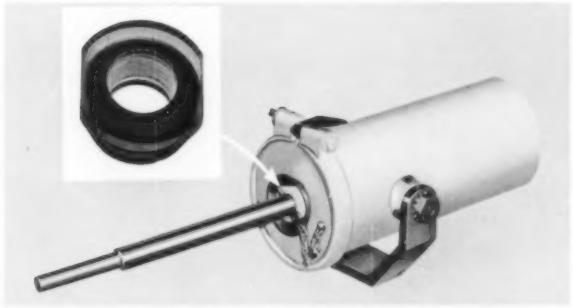


CARD GUIDE requires molding to close tolerances and minimum change in dimensions during service. Molded of LEXAN resin, the part shows excellent dimensional stability under varying conditions of moisture and at high temperatures. LEXAN resin is self-extinguishing—important in this application. (Molded for International Business Machines Corp. by Consolidated Molded Products Corp., Scranton, Pa. and Quinn-Berry Corp., Erie, Pa.)

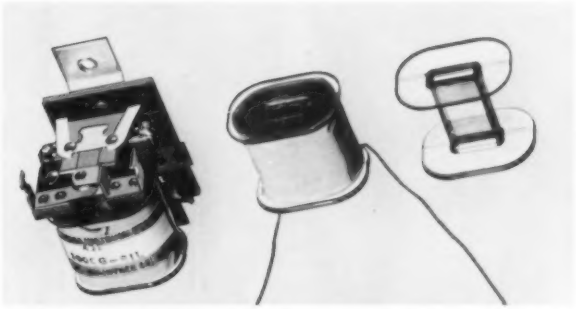


IMPELLERS molded of LEXAN resin replace bronze in jet pumps. Outperforming metal, LEXAN resin gives exceptional impact strength plus ability to withstand 280°F without distorting. LEXAN impellers withstant abrasive wear better than bronze and are unaffected by water or dilute acid. Impeller halves can be separately molded and then solvent-cemented. (Molded for Sta-Rite Products, Inc., Delavan, Wis. by Modern Plastics Corp., Benton Harbor, Michigan, and Santay Corp., Chicago, Ill.)

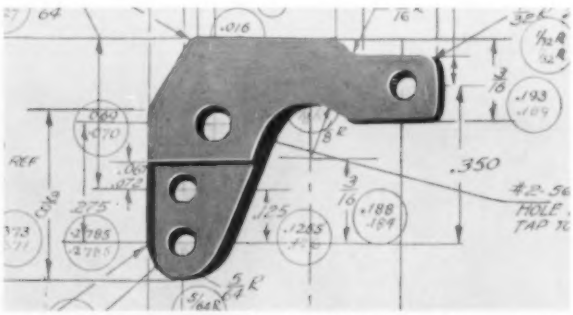
POLYCARBONATE PLANTS TO SOLVE PROBLEMS LIKE THESE



EMERGENCY-BRAKE BUSHINGS of LEXAN resin help trucks come to a safe stop. Before LEXAN bushings were used, the hole for the piston at the end of the activating cylinder quickly wore oblong, allowing road dirt to enter and cause leakage of the inner seal. The plastic's resistance to wear, heat and grease makes it ideal for this critical use. (Brake manufactured by MGM Brakes, Inc., Cloverdale, Calif. Bushings by Automatic Plastic Molding Co., Berkeley, Calif.)

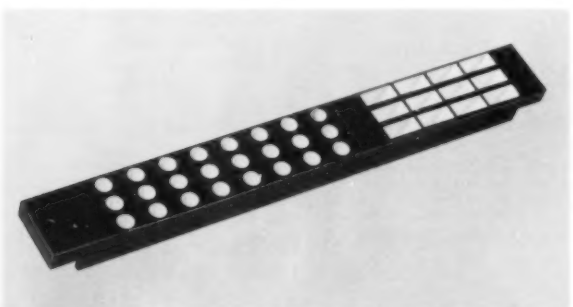


COIL FORM must not distort at temperature above 200°F under stresses caused by tightly wound wire. LEXAN resin provides heat distortion temperatures of 280-290°F under load. A good dielectric, LEXAN resin is resistant to oxidation at high temperatures and is non-corrosive even when used with very fine Class F magnet wire. (Molded for Sigma Instruments, Inc., So. Braintree, Mass. by Waterbury Companies, Inc., Waterbury, Conn.)

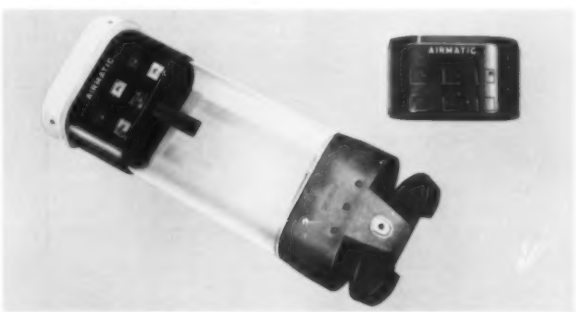


INSULATOR BLOCK of LEXAN resin helps insure trouble-free performance of electrical counter. Not much bigger than a dime, the part must maintain severe tolerances. It takes −85° to +280°F without distortion. The dimensional stability of LEXAN resin lowers cost of the part, permits replacement of materials which required costly machining to attain accurate dimensions. (Molded by Fred Knapp Engraving Co., Racine, Wis., for Abrams Instrument Corp., Lansing, Mich.)

FUSE HOLDER CAPS make use of the transparency and heat resistance of LEXAN polycarbonate resin. Lamp shining through LEXAN cover indicates blown fuse. Plastics previously used softened under the high temperature encountered in naval equipment. LEXAN resin was also selected for its good dielectric properties in the holder, which is rated up to 600 volts and 60 amps. (Molded by B&B Plastics, Oakville, Conn. and Engineered Plastics, Inc., Watertown, Conn. for Fuse Indicator Corp., Boston, Mass.)



LAMPHOLDER TERMINAL BLOCK is used inside electronic equipment where heat is difficult to dissipate. LEXAN polycarbonate resin replaced another thermoplastic which melted under severe thermal conditions. The part is molded with black resin and painted white in the lampholder holes. (Molded by Booker & Wallestad, Minneapolis, Minn. for Remington Rand Univac Div. of Sperry Rand Corp., St. Paul, Minn.)



"WARHEADS" for pneumatic tube systems take advantage of the high impact strength and dimensional stability of LEXAN resin. The good electrical properties of the thermoplastic permit placement of all electrical control elements in the head. LEXAN resin resists wear and tear and saves cost of repair and replacement in these parts, which undergo friction at speeds as high as 20 mph. (Molded for Airmatic Systems Corp., Saddle Brook, N. J. by Berkeley Engineering and Manufacturing Co., Berkeley Heights, N. J.)

PROPERTIES OF LEXAN POLYCARBONATE RESIN

	Property	Value	A.S.T.M. Test
PHYSICAL PROPERTIES	Color	Light amber, transparent	—
	Specific gravity	1.20	D 792
	Odor	None	—
	Taste	None	—
	Refractive index at 25°C	1.586	—
	Rockwell hardness	M70, R118	D 785
	Abrasion resistance, Taber abraser with CS-17 wheel	7–11 mg/1000 cycles	D 1044
	Impact strength, notched Izod, ⅛" specimen	12–16 ft-lb/in. of notch	D 256
	Impact strength, unnotched Izod, ⅛" specimen	>60 ft-lb/in.	D 256
	Tensile-impact	600–900 ft-lb/cu in.	—
	Tensile yield strength	8,000–9,000 psi	D 638
	Tensile ultimate strength	9,000–10,500 psi	D 638
	Tensile modulus	320,000 psi	D 638
	Elongation	60–100%	D 638
	Compressive strength	11,000 psi	D 695
	Compressive modulus	240,000 psi	D 695
	Flexural strength	11,000–13,000 psi	D 790
	Flexural modulus	375,000 psi	D 695
	Shear yield strength	5,400 psi	D 732
	Shear ultimate strength	9,200 psi	D 732
	Light transmission (⅛ in. thick disc)	75–85%	—
	Water vapor permeability	$3–4 \times 10^{-8}$ g/cm/hr/cm²/mm Hg	—
	Nitrogen permeability	0.012×10^{-8} cc(STP)/mm/sec/cm²/cm Hg	—
	Carbon dioxide permeability	0.32×10^{-8} cc(STP)/mm/sec/cm²/cm Hg	—
	Bulk factor of pellets	1.7	—
	Poisson's ratio	0.38	—
	Modulus of rigidity	116,000 psi	—
	Deformation under load, 4000 psi 77°F	0.2%	D 621
	158°F	0.3%	
	Fatigue endurance limit (Wohler method), 1800 cycles/min., 73°F, 50% RH	2000 psi	
	Water absorption, 24 hr. immersion	0.2%	D 570
	equilibrium 73°F	0.35%	
	equilibrium 212°F	0.58%	
THERMAL PROPERTIES	Heat distortion temperature	264 psi: 280°–290°F 66 psi: 283°–293°F	D 648
	Mold shrinkage	0.005–0.007 in./in.	D 955
	Thermal conductivity	4.6×10^{-4} cal/sec/cm²/°C/cm	—
	Coefficient of linear thermal expansion	3.9×10^{-5} in./in./°F	D 696
	Flammability	Self-extinguishing	D 635
	Brittle temperature	<−135°C	D 746
	Specific heat	0.30	Bulletin 157
	Deformation under load on 0.5 in. cube	Temp., °F: 158, 158, 77, 77 — Load, lb: 1000, 500, 1000, 500 — Deformation, %: 0.282, 0.080, 0.220, 0.101	D 621

ELECTRICAL PROPERTIES		−30°C	−3°C	23°C	100°C	125°C	A.S.T.M. Test
	Dielectric constant						
	60 cycles	3.12	3.14	3.17	3.15	3.13	D 150
	10^6 cycles			2.96			D 150
	Power Factor						
	60 cycles	0.005	0.004	0.0009	0.0009	0.0011	D 150
	10^6 cycles			0.010			D 150
	Volume resistivity, ohm-cm	$>10^{17}$	$>10^{17}$	2.1×10^{16}	2.1×10^{15}	2.7×10^{14}	—
	Arc resistance,						D 495
	stainless steel strip electrodes			10–11 sec			
	tungsten electrodes			120 sec			

	25°C	100°C	
Dielectric strength, short time	3,910 v./mil at 1.5 mils 3,080 v./mil at 3.0 mils 2,560 v./mil at 4.7 mils 1,130 v./mil at 23.0 mils 400* v./mil at 125.0 mils	3,380 v./mil at 3.0 mils 1,250 v./mil at 23.0 mils 600* v./mil at 125.0 mils	D 149
Resistance to electron beam radiation	No change up to 5×10^7 r dosage		

*(*The step-by-step values are essentially the same as the short time values for the 125-mil pieces)*

Chemical Materials Department, Section PE
General Electric Company, Pittsfield, Mass.

☐ Send me literature on LEXAN resin

☐ My application area of interest is_____

Name_____

Title_____

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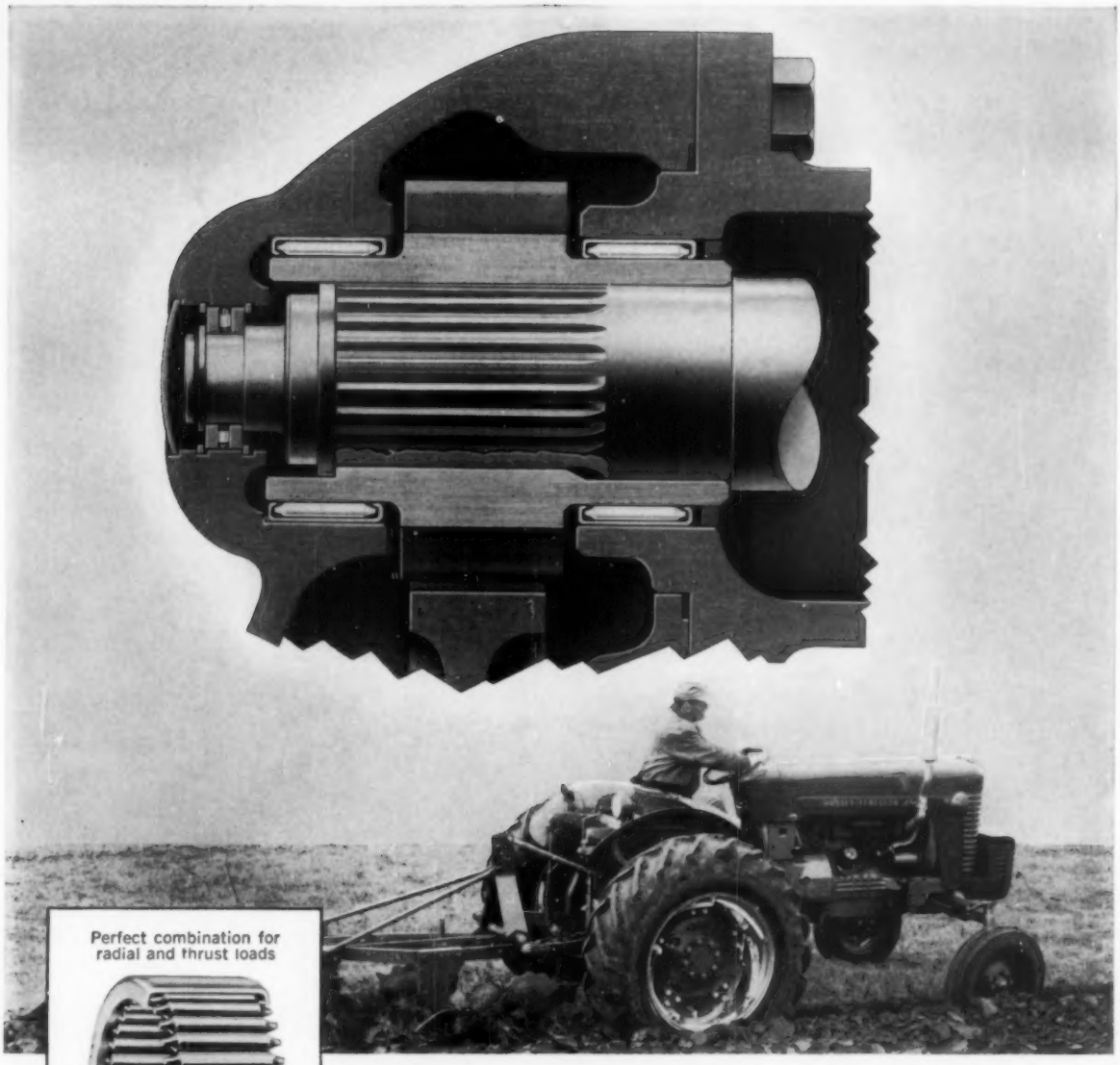
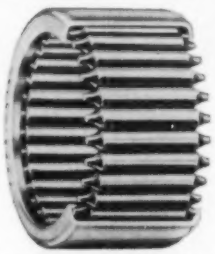


Perfect combination for radial and thrust loads



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For the big pull in tractor performance... Torrington Needle and Needle Thrust Bearings

On the world-famous Massey-Ferguson Model 85 Tractor more than 40 Torrington Needle Bearings and Needle Thrust Bearings are used to smooth the transmission of power, operate the power steering, and to provide improved bearing efficiency and operation.

One outstanding application is the drop axle gear set, pictured above. Here, with their full complement of small diameter rollers, two 2¾″ shaft size Torrington Needle Bearings provide higher radial load capacity than any other bearings of comparable cross section. To handle the thrust load, a single Torrington Needle Thrust Bearing, with two races, is used to complete the bearing team. The result is smooth, efficient, reliable performance – at greatly reduced cost over bearing arrangements previously used in this type of application.

The combination of Torrington Needle Bearings and Needle Thrust Bearings pays off wherever compactness and high bearing capacity are needed. For advice on *your* application, call on Torrington – maker of every basic type of antifriction bearing.

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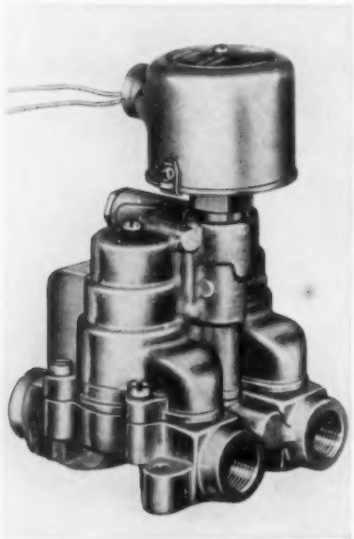
THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

(Advertisement)

Why Name an Air Valve "Mach 2"?

"Mach 2" is the name of a new Crescent® Air Valve now ready for distribution to industry. An identifying name is desirable for this valve to point up the new kind of performance it brings to air control and to distinguish it from the other valves in the long-established Crescent® line.



The new Crescent "Mach 2" 4-Way Valve. (Half-inch pipe size shown.)

A Breakthrough in Cycling Speed

Actually these Crescent® "Mach 2" 3-Way and 4-Way Air Valves represent a breakthrough, as the name suggests. For years a cycling speed of 600 to 700 cycles a minute seemed to be the limit for solenoid pilot valves. The original Crescent 4-Way Valves attained that speed a long time before other valves even approached it. Now, the "Mach 2" has been tested and rated for 1000 cycles per minute continuous duty. During a two-hour test at a speed of over 1500 cycles per minute the coil temperature stabilized at 7°C below the maximum code limit for class A coils. Cycling speeds as high as 2100 have been successfully reached for intermittent periods of 20 minutes.

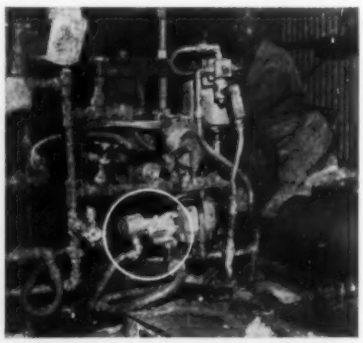
Brings New Dependability

We realize that such high cycling speeds are seldom needed. However, speed and endurance seem to be Siamese twins. Here's why: (1) Speed depends on an extremely short stroke of the solenoid plunger (3/32 of an inch—approximately the thickness of a nickel—in the new "Mach 2"). This greatly reduces coil heating and, as heat goes down, coil life expectancy goes up. (2) High cycling speeds demand a drastic reduction of friction in the solenoid and pilot valve section. In the "Mach 2" pilot valve, a tiny ball seats on "O" rings at both ends of a pilot cartridge. The ball moves freely, independent of the seals. There is no "O" ring drag on the pilot plunger because it requires no seals; where there is no friction there can be no wear.

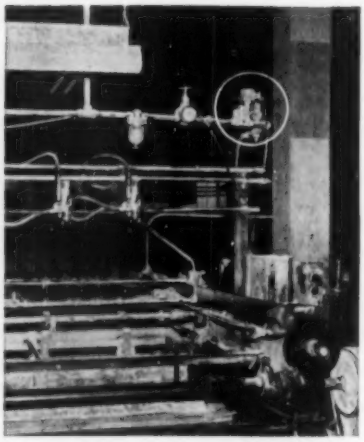
Similarly, the main valve seats seal on "O" rings. Metal shoulders take the shock in such a way that the "O" ring seal is merely kissed by the seat in the sealed position; since they are only minutely flexed they don't fatigue or lose their resilience.

100 Million Cycle Guarantee

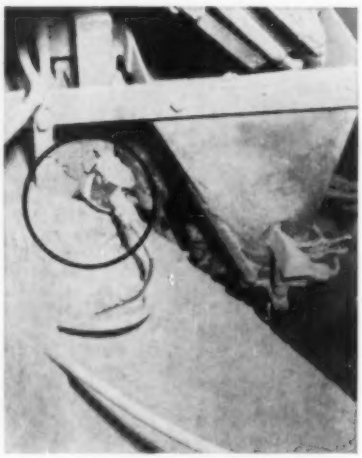
Because of the short solenoid plunger stroke and the elimination of friction, there seems to be no limit to the endurance of the solenoid coils in "Mach 2" Valves. We back up this statement by guaranteeing the coil life for a minimum of 100 million cycles. For six years "Mach 2" Valves have undergone test. Valves have been placed in some of the toughest applications we could find to test their performance capabilities in actual service before introducing them to the market. Some were installed in plants where they were subjected to very fast-cycling, continuous operation. Others have been operating where they are exposed to excessive dirt, dust and dampness, and in all cases the "Mach 2" Valves are performing flawlessly. In fact, some operators balked at having us remove them for inspection. To test the new waterproofing treatment of the "Mach 2" coils, one of the units was completely submerged in a container of water on April 26, 1959, and it is still functioning perfectly.



Crescent "Mach 2" 4-Way Valve on a roofing paper machine. This machine operates 24 hours per day, 7 days per week.



Large printing press used to imprint cardboard cartons. "Mach 2" 3-Way Valve controls spray nozzles which apply "offset spray." Production speed of this machine is 2000 cycles per hour.



This Crescent "Mach 2" 4-Way Valve operates the hopper doors at a cement batching plant. The valve has been operating at 1400 cycles per day surrounded by dry cement. We actually had to dig the cement away from the valve to get a picture.

Write for the "Mach 2" Catalog

Crescent® "Mach 2" Solenoid Pilot Operated Air Valves represent a significant breakthrough in "the cycling speed barrier" and in valve life and operating dependability. We hope you will approve of the unusual name, "Mach 2." We know you will approve of the low-cost, downtime-free performance the "Mach 2" will deliver on your tough jobs. Please write to Barksdale Valves, 5125 Alcoa Avenue, Los Angeles 58, California, and request an advance copy of the "Mach 2" catalog.

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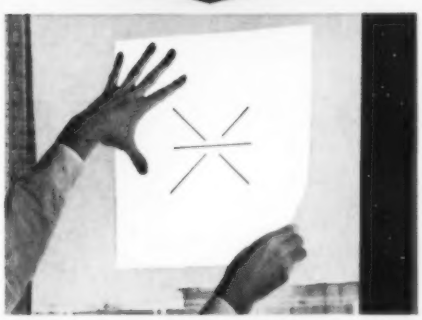

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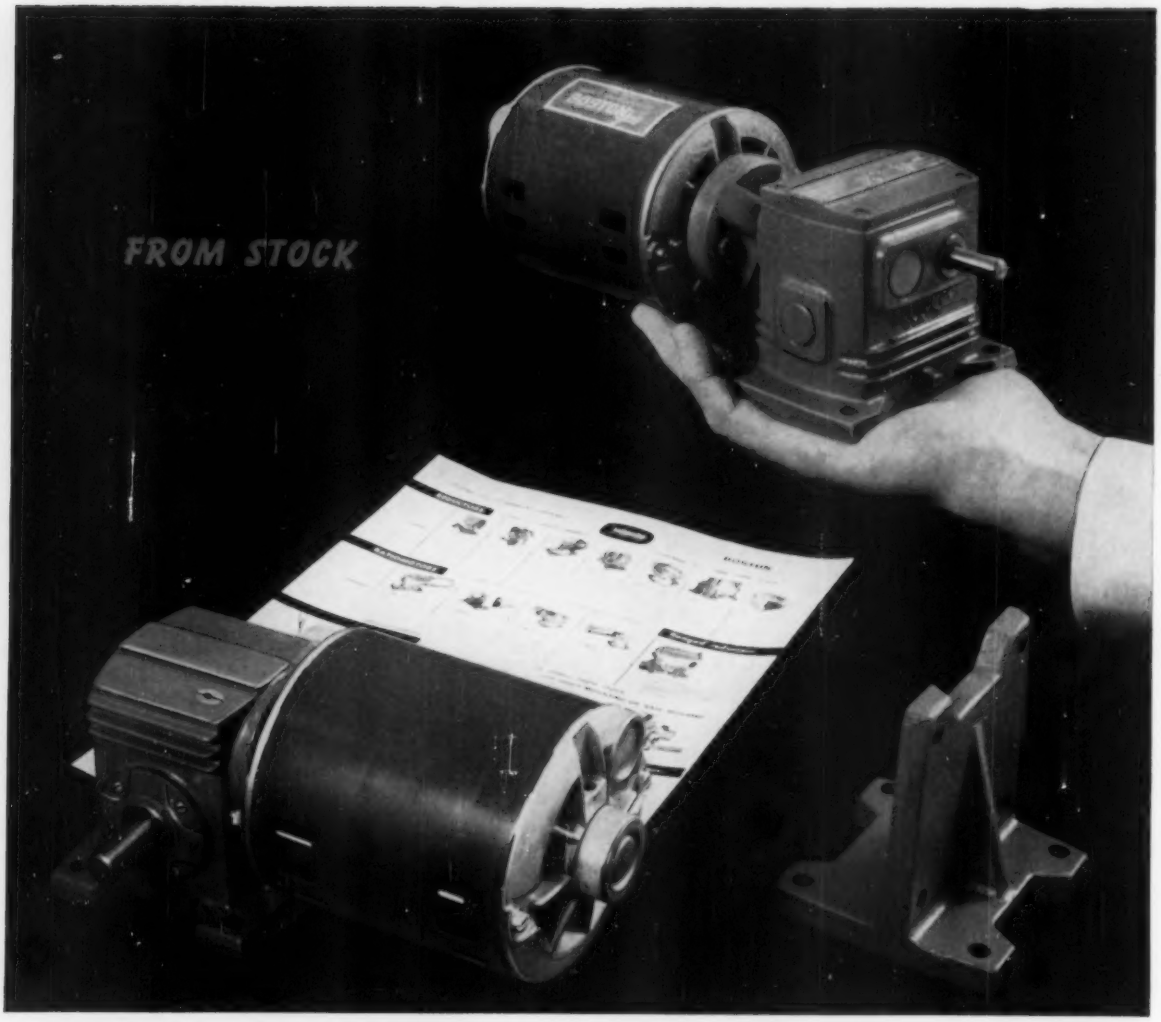

THE NEW M109 Ratiomotor (foreground) for horizontal right angle drives is furnished with 1/20 hp or .035 hp motor. Output speeds range from 43.8 to 350 RPM. New standard mounting bracket shown permits easy mounting in many positions. The NEW MW109 (in hand), for horizontal parallel drives, is also furnished with 1/20 hp or .035 hp motor. Output speeds range from 1.9 to 70 RPM.

NEW Ratiomotors meet demand for

BOSTON Gear efficiency in "pint-size" power packages

Now, you can get BOSTON Gear quality and lasting economy in speed reducers for drives as low as .035 hp. Two new units, designed for space-saving, provide a wide range of output speeds.

When you need worm-geared reducers, you'll find any type and ratio you want in the big line of over 1600 BOSTON Gear 100 Series Reductors and Ratiomotors . . . and you can get it FROM STOCK. Catalog No. 57, with the NEW PRODUCTS Supplement, lists full information. Get your copy. Boston Gear Works, 71 Hayward St., Quincy 71, Mass.

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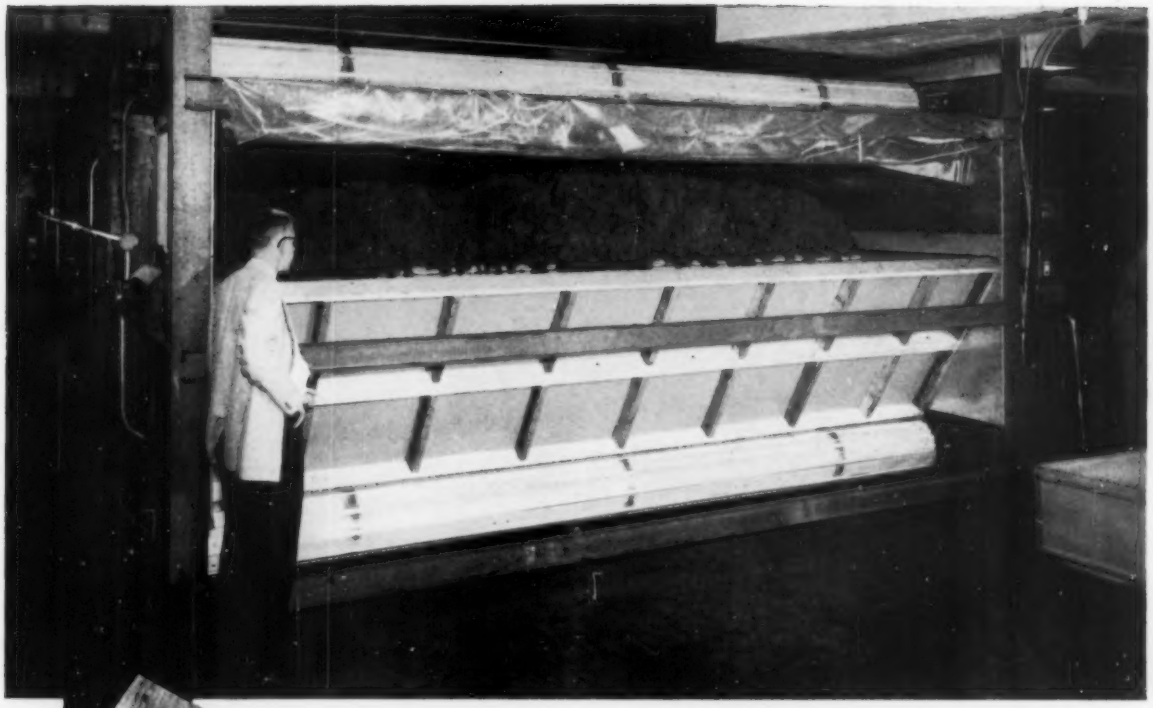

from factory floors...to tobacco conveyors...

GAMBLE solves problems with WOOD!

PROBLEM: Ordinary industrial wood block flooring was breaking up rapidly at heavy-traffic spots like loading docks, intersections, and aisles.

SOLUTION: Wood engineers at Gamble Brothers developed a laminated end-grain hickory block which lasts up to 10 times longer, despite punishing loads that quickly break up ordinary flooring.

PROBLEM: Tobacco conveyors required long orifice-forming slats whose dimensions would not change, even after use in a moisture-control operation in cigarette-making.

SOLUTION: Gamble Brothers designed a laminated slat of maximum dimensional stability, bonded by water-proof, heat-proof, non-taste-imparting adhesives. Our facilities enabled us to build the slats under environmental conditions identical to those to be experienced at end use.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers — a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4617 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

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CIRCLE 41 ON READER SERVICE CARD

CIRCLE 42 ON READER SERVICE CARD →

Now! Make any pushbutton station you want with new, completely versatile Cutler-Hammer oiltight pushbuttons

Choose from a complete line of operators, get greater circuit flexibility than with any other make

To meet today's need for a broad range of oiltight pushbuttons, Cutler-Hammer gives you a new versatile line.

You can get these rugged proved pushbuttons in one hole or base mounting, six bright colors. More than thirty different circuit arrangements are available plus hundreds of varieties of stations in standard arrangements of up to 25 elements. And you can get up to 8 circuits on one pushbutton. The flexible oil resistant diaphragm behind the button is designed to stay soft and pliable permanently.

With Cutler-Hammer pushbuttons you can get more control in less space, too, because they use 40% less behind the panel space than the next smallest unit.

Get all the facts by sending for the colorful brochure, "MASTER DESIGN" which tells you all about the Cutler-Hammer line. Ask for Pub. LO-104.

What's new at Cutler-Hammer? You can see the newness in the products coming from Cutler-Hammer, like the new smaller pushbuttons; in the new manufacturing facilities; in the new engineering ideas. All to give you better service today and in the future. Contact the nearest Cutler-Hammer sales office or your Cutler-Hammer distributor.

WHAT'S NEW? ASK...

CUTLER-HAMMER

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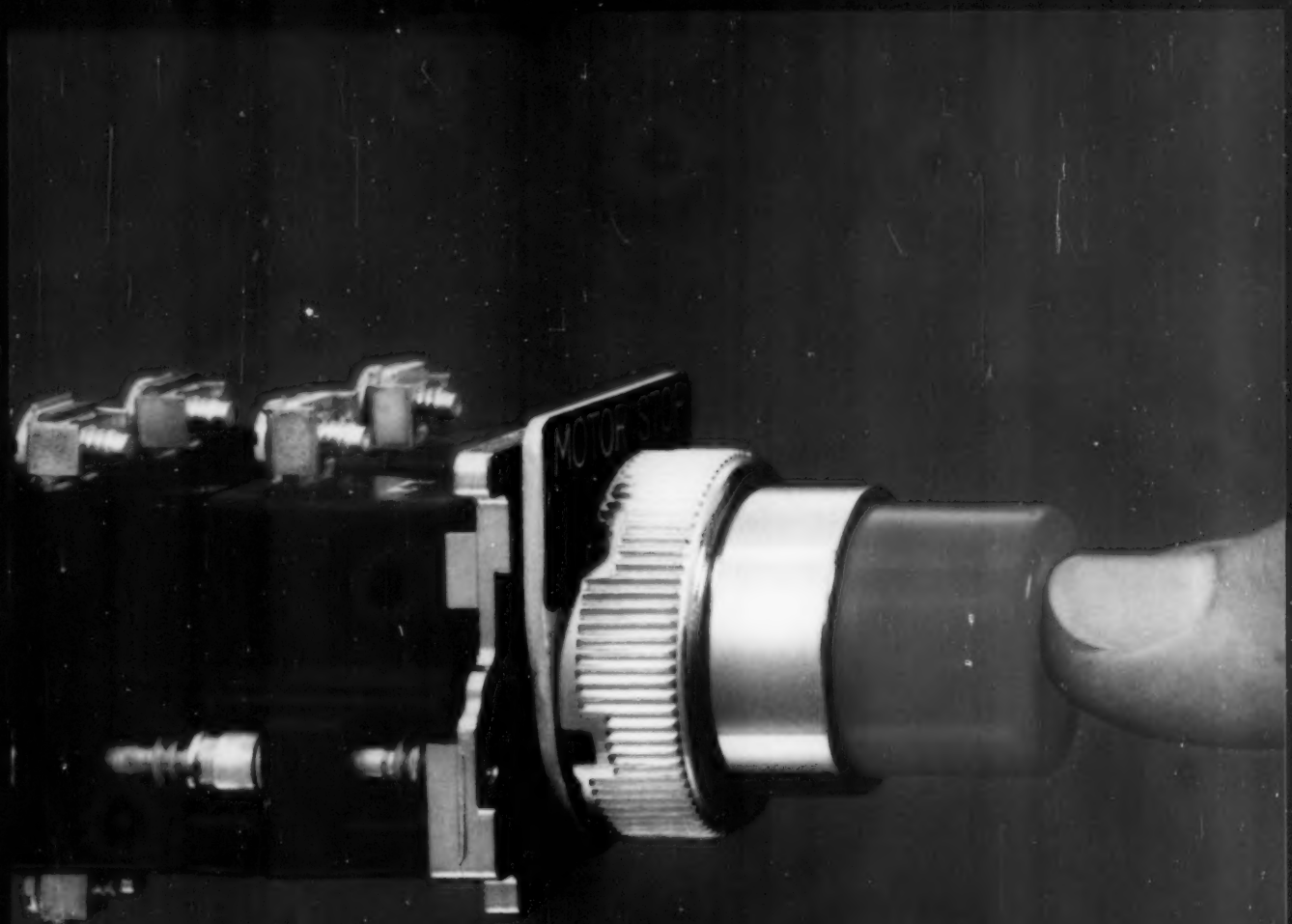

NEW ILLUMINATED PUSHBUTTON. Newest addition to the versatile line.

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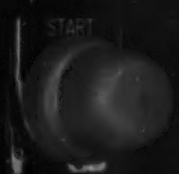

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Titeflex, Inc., Meets Aircraft Fuel, Lubrication and Hydraulic Line Specifications with

HANDY & HARMAN BRAZE 541

Titeflex operator brazes assembly with torch and hand-fed Handy & Harman Alloy BRAZE 541. *Titeflex is unique in that it makes flexible hose assemblies from raw material to end product—"From End to End, Inside and Out, made RIGHT In Our Own Plant."*

This Springfield, Massachusetts, manufacturer of aircraft and missile fuel, lubrication and hydraulic lines finds that silver alloy brazing with Handy & Harman BRAZE 541 meets rigid operating requirements "all the way down the line."

The tubing and fittings of many of the wide range of assemblies made by Titeflex are 321, 316 and 347 stainless steel and Monel. Brazing is a hand torch, wire and HANDY FLUX operation.

BRAZE 541 is a plastic alloy which melts at 1325° F and flows at 1575° F. Its strength—in shear—at elevated temperatures is 21,500 psi at 500° F and 15,000 psi at 750° F. This alloy's ductility in resisting stress and vibration is very high and its resistance to oxidation and corrosion is equally impressive. The composition of BRAZE 541 is 54% silver, 40% copper, 5% zinc and 1% nickel. It meets AMS Specification 4772.

Aircraft and missile component manufacturers and fabricators are finding—to their and their products' benefit—that Handy & Harman silver alloy brazing is the full and *final* solution to their metal-joining problems. BRAZE 541 is but one of a large family of Handy & Harman alloys, for both low and high temperature applications. We would like to more fully acquaint you with BRAZE 541 and with the advantages that come naturally to silver brazing as a metal-joining (both ferrous and nonferrous) method. Handy & Harman, 82 Fulton Street, New York 38, N. Y.

FOR A GOOD START: BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits... includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

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IMPLEX, the high impact acrylic, goes where the tough jobs are . . . where great strength and rigidity, plus resistance to staining, are important selling points for a product. The fishing reel cover, transistor radio case and water-powered knife sharpener housing shown above* have rugged durability because they are molded of IMPLEX. This Rohm & Haas molding material also provides an attractive appearance by imparting high surface gloss and rich colors. Our design staff and technical representatives will be pleased to help you use IMPLEX for your present and prospective products—to your advantage. Just write and tell us about a specific project.

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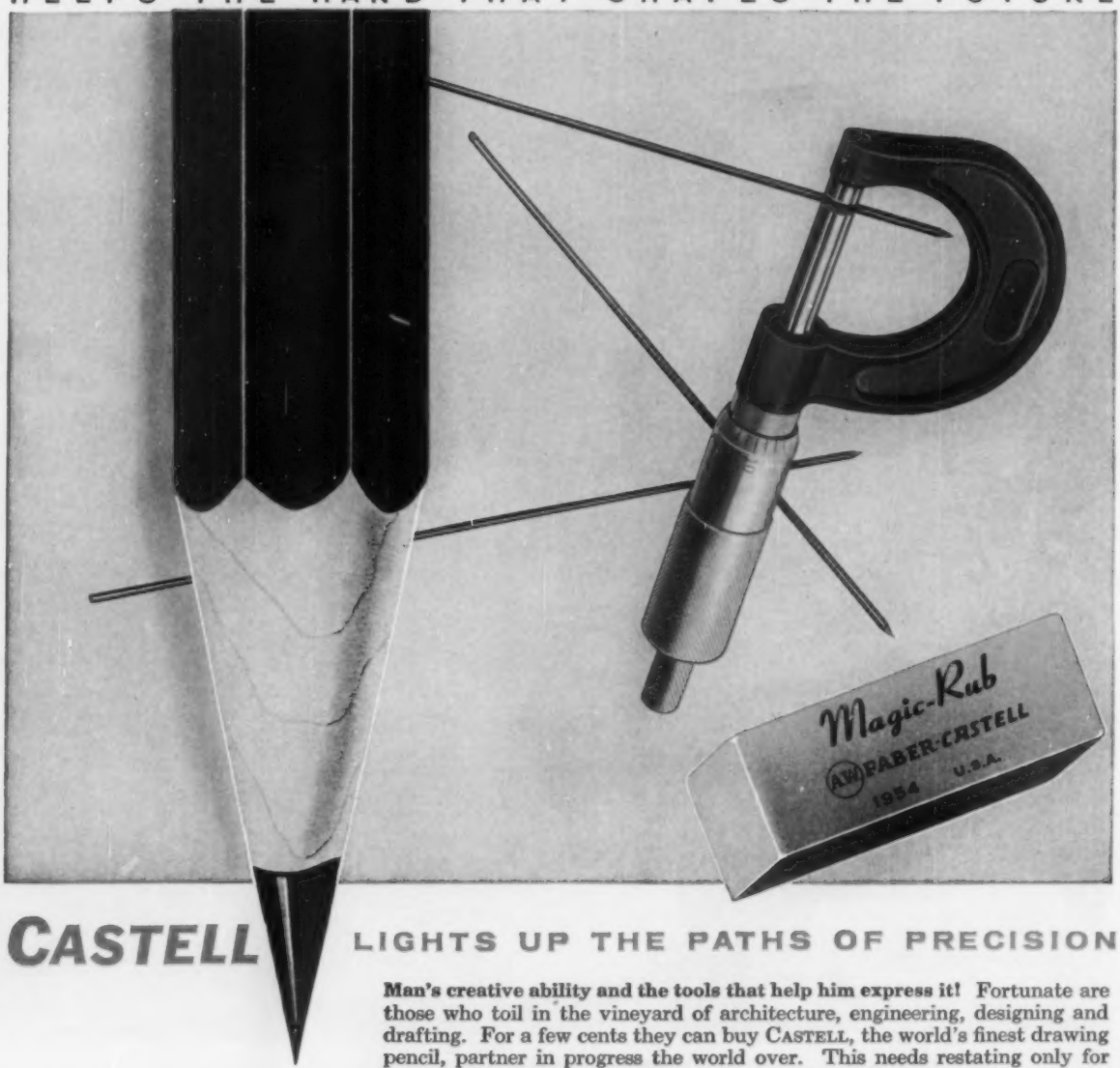
IMPLEX

CIRCLE 45 ON READER SERVICE CARD

HELPS THE HAND THAT SHAPES THE FUTURE



CASTELL LIGHTS UP THE PATHS OF PRECISION

Man's creative ability and the tools that help him express it! Fortunate are those who toil in the vineyard of architecture, engineering, designing and drafting. For a few cents they can buy CASTELL, the world's finest drawing pencil, partner in progress the world over. This needs restating only for the benefit of the young now coming up in the profession. Old seasoned hands have known it for generations. CASTELL is an unquestioned fact in a creative man's life.

#9000 CASTELL Pencil with world's finest natural graphite that tests out at more than 99% pure carbon. Exclusive microlette mills process this superb graphite into a drawing lead that lays down graphite-saturated non-feathering lines of intense opacity for cleaner, more durable originals and clearer, sharper prints. Extra strong lead takes needlepoint sharpness without breaking or splintering. Smooth, 100% grit-free consistently uniform pencil after pencil, in full range, 8B to 10H.

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CASTELL Pencils and Leads draw perfectly on all surfaces, including Cronar and Mylar base films. Give graphite-saturated lines, easy to erase, no ghosting — excellent reproduction.

***CASTELL** Rubberless MAGIC-RUB ERASER soaks up graphite without abrading drawing surfaces, and residue rolls off. Leaves no "oil" stain or "ghost." Tests highest in ease of use, line removal and non-smudging. Tests first on Cronar and Mylar base films. For all papers and vellums.*

#9800SG CASTELL LOCKTITE TEL-A-GRADE Holder, perfectly balanced, lightweight, with new no-slip functional grip that lightens finger pressure without slipping, and *relieves finger fatigue.* Unique degree lead indicating device.

#9030 CASTELL Refill Lead, matching exactly #9000 pencil in quality and grading, degrees 7B to 10H, packed in reusable plastic tube with gold cap.
Many other styles and colors of CASTELL Pencils, Holders and Refill Leads.

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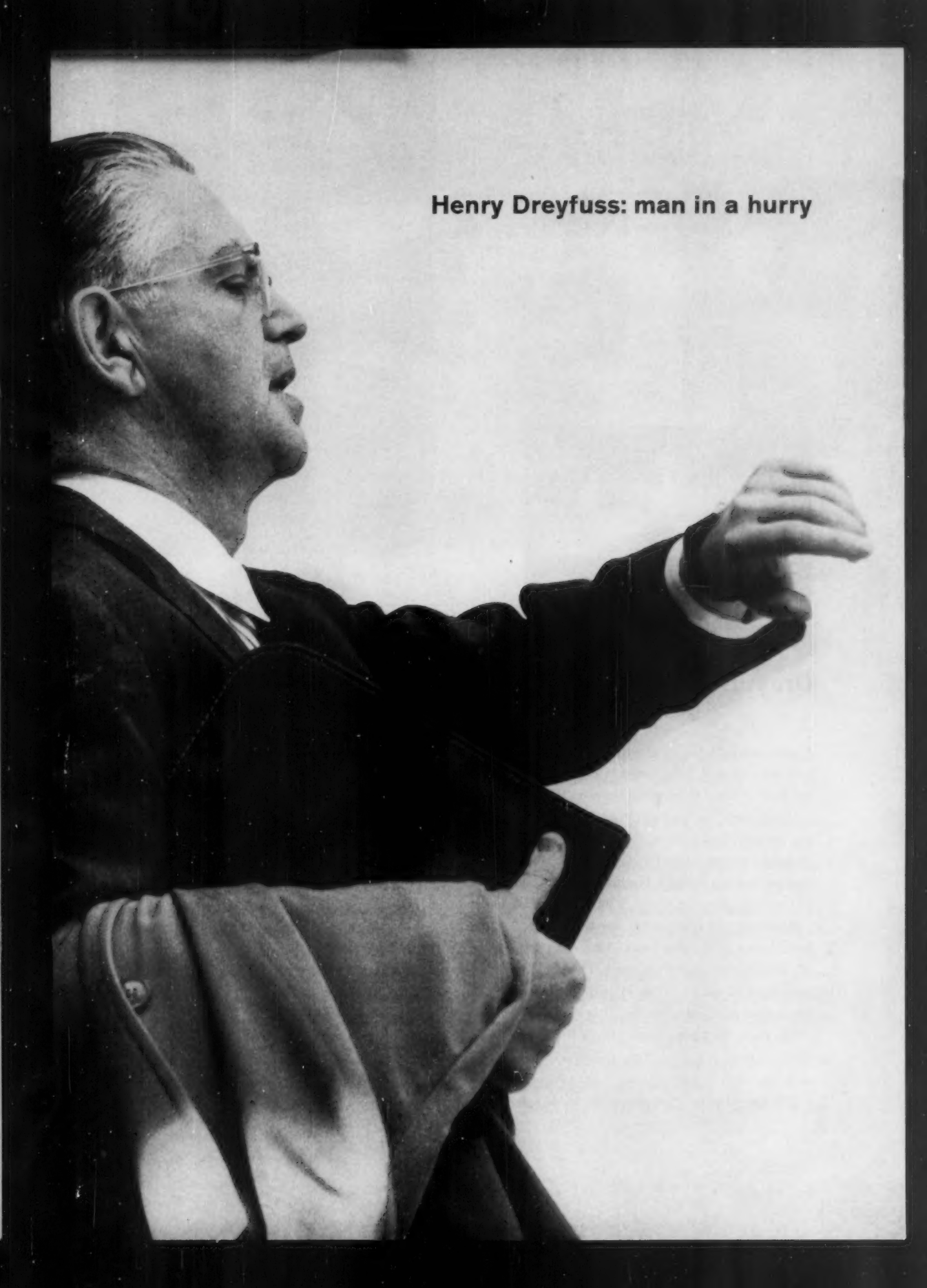
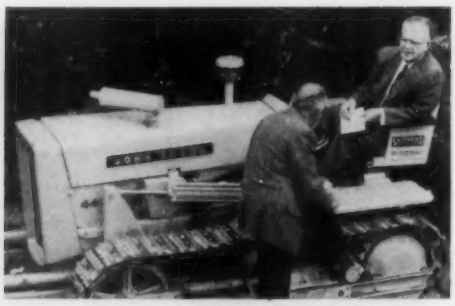


Henry Dreyfuss: man in a hurry



Dreyfuss talks design

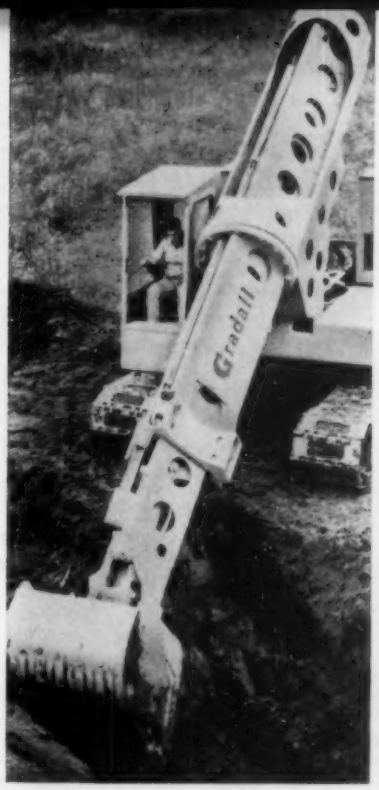
If you could get Henry Dreyfuss to sit still long enough for a caricature, the drawing would inevitably show him with his coat half on and briefcase in hand. Most likely, he would be on his way to the airport. He's on the East Coast a third of his time, on the West Coast a third, and the other third in between.

Henry Dreyfuss has been busy ever since he gave up scenery design in the late Twenties and helped pioneer the business that is now called industrial design. In the early days, he gave a new look to everything from hinges to pianos, cigarette lighters to tractors. Today he can look back on a career of redesigning vacuum cleaners and gas stations, bowling alleys and ship interiors, typewriters and dental equipment, magazine formats and military strategy rooms, plumbing fixtures and the Nike missile launcher.

But Henry Dreyfuss is not one to look back. There are designs on his boards today that will influence our lives twenty years from now. "Time," he says, "is one of the designer's big problems. A design assignment is often three years in development. The item may not be on the market for another three to ten years. After it's introduced it will be in use for any number of years. In order to design that far ahead, our ideas have to be fresh, advanced and sprightly. It is a challenge to have to think as far ahead as we do."

One thing that goes a long way is the Henry Dreyfuss design credo, and it is all about people. "It says in effect," Dreyfuss states, "that the item is going to be ridden in, sat on, looked at, talked into, operated or in some way used by people. If the point of contact between the product and people causes friction, we have failed.

"On the other hand, if people are made safer, more comfortable, more eager to purchase, more efficient, or



just plain happier—we have succeeded." And succeed Dreyfuss does, by following this yardstick for effective industrial design: 1. Safety and convenience of use. 2. Ease of maintenance. 3. Cost, including tooling, production and distribution. 4. Sales appeal. 5. Appearance.

Selection of the right material for the job plays an important role in satisfying each of the five requirements. As a matter of ethics and sheer common sense, Henry Dreyfuss, like any member of the American Society of Industrial Designers, will not endorse any one material. "We have worked with all materials. What we want is the material that is right for the job. We look for the material that combines reasonable cost with the ability to be fabricated economically, and at the same time will give the product the built-in quality and durability it needs to sell well." With no-nonsense requirements like that, it is not surprising that a great many Dreyfuss-designed products use steel in one way or another.

Steel has strength, integrity and honesty. Steel is what the designer is apt to call a 'natural.' Dreyfuss feels that the public's image of steel depends largely on the product itself. A massive steel vault door conjures up an image of strength, imperviousness. Stainless Steel tableware suggests style and modernity. Steel curtain wall panels give buildings the look of tomorrow.

The moral is this: steel has been with us for ages, yet it is the modern metal, the metal of the future. Its enduring modernity will continue to be recognized, and used, by designers like Henry Dreyfuss.

(turn the page for a new look at steel)

USS TRADEMARK **United States Steel**

designing with USS High Strength Steels

Good design goes beyond material selection. Once the choice has been made, the designer's job is to take full advantage of the material's properties. Few materials offer designers as much opportunity as high strength steels.

COR-TEN Steel was developed by U.S. Steel and first used in 1933.

USS COR-TEN Steel is a name that has become a byword in design circles. It is a time-tested, high strength low-alloy steel. Structural designers welcomed COR-TEN Steel because it allowed them to pare dead weight and to lower maintenance costs. As structures, mobile equipment and machinery got bigger and bigger, dead weight became more of a problem. Even when weight could be shaved without stress problems, durability suffered. This high strength steel answered both problems.

Dead weight in stationary structures is costly; in mobile equipment dead weight requires more power to move.

USS High Strength Steels' yield points are all 50,000 psi min. compared to 33,000 psi for structural carbon steel.

Strength did it. COR-TEN brand and other USS High Strength Steels have a 50% higher yield point than structural carbon steel. They permit as much as 33% weight reduction. They have superior resistance to atmospheric corrosion and abrasion, so there is little reason to overdesign. Their fatigue and impact properties are excellent. Here is a quick look at three well-known USS High Strength Steels:

Send for the manual described at the right for a comprehensive guide on how to design with high strength steels.

USS COR-TEN Steel has a yield point 50% greater than structural carbon steel, has four to six times its resistance to atmospheric corrosion. It is used to do any one of these three things: 1) in slimmer sections to cut weight at no strength loss; 2) in equal sections to increase load-carrying capacity, cut maintenance and lengthen life; and 3) any number of combinations of 1 and 2. COR-TEN Steel also has greatly superior paint adherence and is used where a longer interval between repainting is wanted.

USS TRI-TEN Steel, with its 50% higher yield point than structural carbon steel, has superior notch toughness at low temperatures and keeps rugged equipment operating even in sub-zero weather. Its high endurance limit makes TRI-TEN Steel ideal for mobile equipment that must take repeated loading and reversals of stress. It is a natural for welded structures and bridges.

MAN-TEN Steel costs only about 20% more than structural carbon steel; TRI-TEN Steel about 36% more, and COR-TEN Steel 42% more.

USS MAN-TEN Steel also has a 50% higher yield point than structural carbon steel, and is the low-cost member of the family. Weight reduction as little as 17% with MAN-TEN Steel will save money on material cost alone. MAN-TEN Steel is a tough, durable steel and widely used in earthmoving equipment, truck frames, material handling apparatus and riveted bridges.

High strength steels represent but a few of the over 3000 grades of steel in existence today. United States Steel makes a complete line of high strength steels, as well as constructional alloy, stainless and carbon steels. Bring your design problems to us. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS, COR-TEN, MAN-TEN and TRI-TEN are registered trademarks.

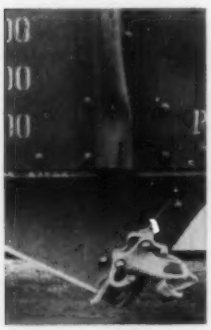
Watch United States Steel's special Christmas show, **The Coming of Christ,** in Color on NBC-TV, Wednesday, December 21, 8:30 P.M., E.S.T.

USS United States Steel

Cranes have to operate in all-weather temperatures and are subject to stress and shock. That's why many of them are made of tough TRI-TEN Steel.

Light standards stay good looking for years because of COR-TEN Steel's outstanding atmospheric corrosion resistance. Paint life is extended. Slim design is made possible by COR-TEN Steel's strength.

TRI-TEN Steel has cut weight and cost of dozens of major bridges. In the bridge shown here, TRI-TEN Steel saved a quarter of a million dollars.



One of the first applications of COR-TEN Steel was in hopper cars for weight reduction and longer life. Today, use of COR-TEN Steel can save hundreds of dollars over the life of a car.

MAN-TEN Steel, used in truck frames and body members, reduces dead weight and increases payload.

The LPG cylinder business uses considerable amounts of MAN-TEN Steel because of its strength, cost and ease of fabrication to lighten the weight.

This mark tells you a product is made of modern, dependable Steel.

Here's a book that is in the hands of thousands of engineers and designers. It is your guide to the design of lighter, stronger equipment and structures.

design manual for high strength steels

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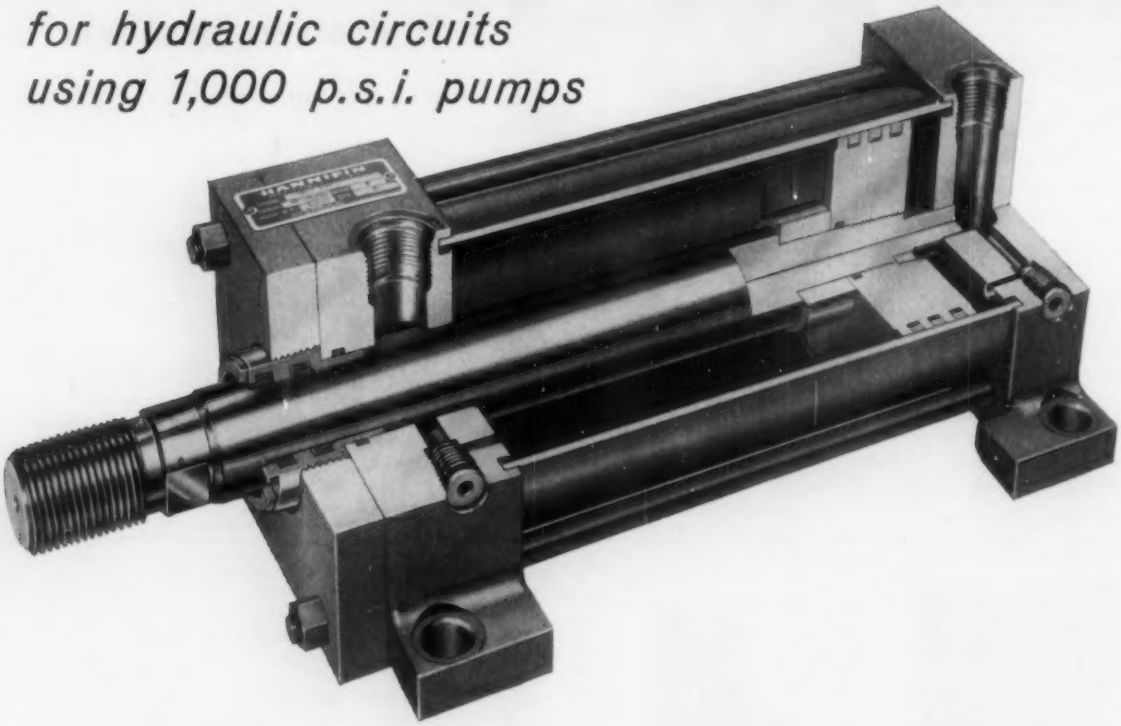

- *A true hydraulic cylinder – not a modified air cylinder*
- *Offered in nine bore sizes – 1" through 8"*
- *Every model withstands at least 1,000 p.s.i. in every bore size*
- *Built to save you money – yet not "built to a price"*

Now, for the first time in hydraulic cylinder manufacture, Hannifin offers a top quality cylinder tailored to the medium-high-pressure hydraulic circuits you operate off 1,000 p.s.i. pumps.

Series "L," the "Thousand Pound Line," is NOT a modified heavy duty air cylinder. It is built for the job . . . with steel heads and steel barrel for full compliance with J.I.C. hydraulic recommendations. Other extra-quality features include an induction hardened and hard chrome plated rod, nodular iron piston with cast-iron piston rings — leakproof "Lipseals®," optional — longer cushions on cushioned models, and the Hannifin-developed bronze cartridge gland with both "Lipseal®" and "Wiperseal" to keep the rod drip-free. S.A.E. straight thread "O" ring ports as recommended by J.I.C. are optional at no extra cost just as they are in the Hannifin heavy duty Series "H" hydraulic cylinder.

Parker-Hannifin field engineering service can help you meet your needs precisely, help you select the proper Hannifin cylinder for any service, air or hydraulic. Call your nearest Parker-Hannifin sales office or write direct for our new bulletin giving all dimensions of Hannifin Series "L" cylinders.

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PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

9077-PEB

LATHE-CUT RINGS vs. MOLDED O-RINGS

Lathe-cut cork-and-rubber rings are compressible. They often permit wider tolerances in the flanges . . . opening the way for worthwhile savings in machining time. And their initial cost is lower.

If you now use molded rubber O-rings, chances are you can reduce costs considerably by changing to lathe-cut rings of Armstrong cork-and-rubber materials. At the same time, it may be possible to effect savings in machining time and inventory costs. Here's why.

A molded O-ring can cause sealing problems if the ring is not exactly the right size in cross section. If the ring is too small, it will not seal. If it is too large, it will prevent flange contact.

The reason, of course, is that rubber is non-compressible. Under pressure it flows laterally, but does not decrease in volume. As a result, rubber O-rings must be made to very close tolerances to allow a perfect fit between flanges.

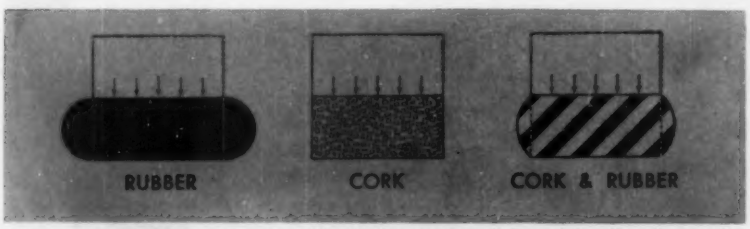

Figure 1. Rubber is non-compressible. Under pressure it flows laterally—does not decrease in volume. Cork is truly compressible. It exhibits no lateral flow under pressure. Cork-and-rubber gives controlled compressibility. Lateral flow can be controlled by varying the composition of the material.

Lathe-cut O-rings of cork-and-rubber compositions offer a number of advantages over molded O-rings. In such compositions, the compressibility can be controlled. The material can be made nearly as incompressible as rubber. The per cent of compression for cork-and-rubber rings may range from 20% to 33%.

This means that wider tolerances are permissible with cork-and-rubber rings, since the lateral flow can be controlled. The result may be a savings in machining time. In some cases, a reduction of inventories may be possible because one size of cork-and-rubber ring may work where two or more molded O-ring sizes might be required. These economies, of course, are in addition to the lower first cost of lathe-cut rings.

Cork-and-rubber O-rings give the imperviousness of rubber, since the rubber binder encloses each cork particle in a continuous matrix. The temperature limits of cork-and-rubber materials vary with the composition of the material and the contained fluids to which they are exposed. In general, continuous operating temperatures should not exceed 300° F.

The solvent resistance of cork-and-rubber compositions is comparable to straight synthetic rubbers of corresponding base polymers. For example, cork-and-chloroprene-type synthetic rubber is normally used with lubricating oils and for general purpose applications where some swell is desired or can be tolerated.

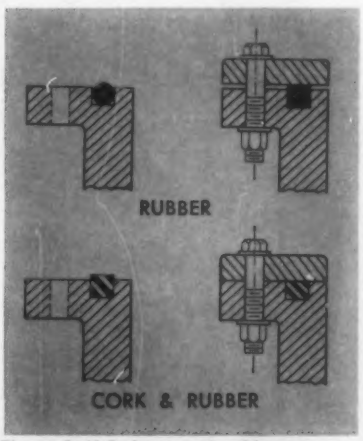

Figure 2. If O-rings made of incompressible rubber are slightly oversized, the joint will not close. Compressible cork-and-rubber rings may be cut to full channel width and from 20% to 33% deeper than the channel.

Cork-and-nitrile-type synthetic rubber provides good gasoline and aromatic-solvent resistance and has less tendency to swell or stick on metal surfaces.

If you have a problem with O-rings, perhaps we can help you. Send complete details of your application to us. And, for a free copy of our Gasket Design Manual, containing detailed information on gasket design and selection, write Armstrong Cork Company, Industrial Division, 7112 Irvin Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

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NEW
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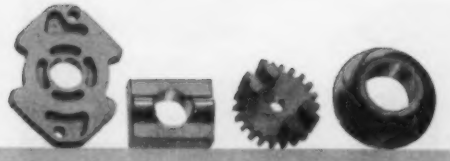


DELCO MORAINE

Division of General Motors, Dayton, Ohio

How to design SALES

Why THE CONVEYOR CO.

ENGINEERING ADVANTAGES . . .

"We specified International equipment because of its excellent reputation and ready acceptance by our customers."*—W. E. SAXE, *President and Chief Engineer, The Conveyor Co., Los Angeles, Calif.

Here's another successful manufacturer who has a strong preference for International Power: "During the early design and testing stages we had the help of International's engineering staff for installation problems or proper application of power," says Mr. Saxe. "Our latest model features a compact, space-saving IH Model UC-60 engine mounted in the rear to power the sweeper mechanism. This is a simple installation, easy to service and repair."

International's wide range of power sizes, with features for extreme adaptability in every size, presents a choice to match most power requirements. A conscientious engineer considers parts and service coverage, ease of maintenance, and reputation of the manufacturer as well as engineering advantages. With International, you can design sales power *and* superior engineering into your product.

SALES POINTS . . .

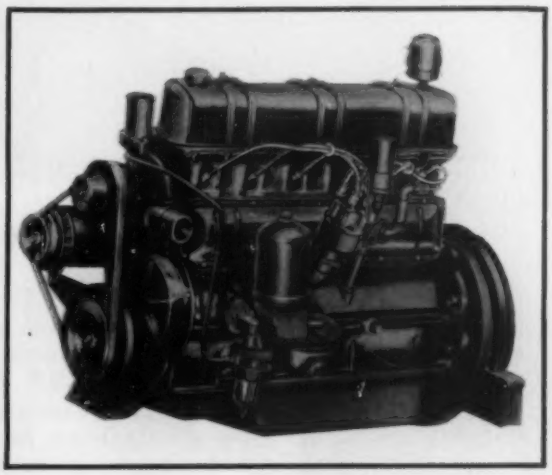
"The complete acceptance of International engines by our biggest users is a wonderful sales asset."*—W. T. LARSEN, *Sales Manager, The Conveyor Co.

Men who sell the Mobil Sweeper line are convinced of the profit-building, sales-clinching advantages of International engines. Here's how Mr. Larsen puts it: "We are able to show sanitation departments and government agencies many examples of years of trouble-free performance and economical operation of IH engines on Mobil Sweepers. This acceptance is world-wide. Our customers in Iran, South Africa, Japan —anywhere in the free world—know that engine service help is only a few hours away!"

Smart salesmen know that most customers back up an engine choice with years of experience. And years of experience, as reported by users from coast to coast, prove the value of International Power in heavy-duty equipment.

POWER into Your Products

specifies INTERNATIONAL POWER...



International UB-264 gasoline engine delivers 111 hp @ 2,800 rpm, provides perfect power for the Mobil Sweeper shown at left. There are 35 carbureted and diesel engines in the International line—16.8 to 385 max. hp.

CUSTOMER ACCEPTANCE...

"Our city equipment must be efficient, safe, dependable and long-lasting. IH-powered Mobil Sweepers meet these requirements."—R. G. BARHITE, Director of Public Works, City of Downey, Calif.

"Our first Mobil Sweeper proved itself in 34,000 sweeping miles, as have other Mobil Sweepers in neighboring towns," reports Mr. Barhite, shown at right with Street Superintendent Mel Harldson. "Our new model, also with International power, is doing an excellent job!"

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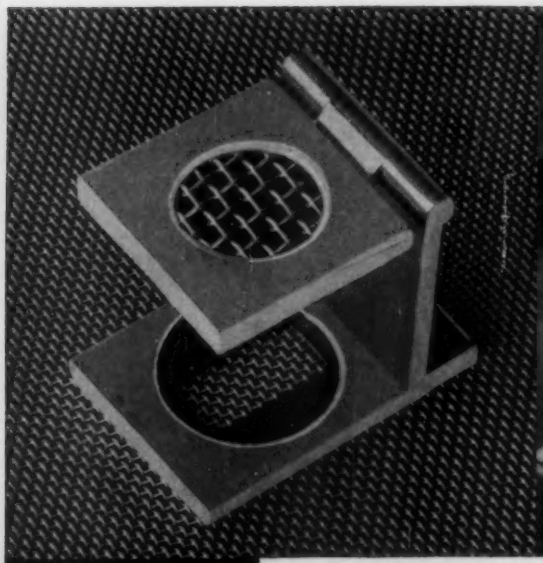

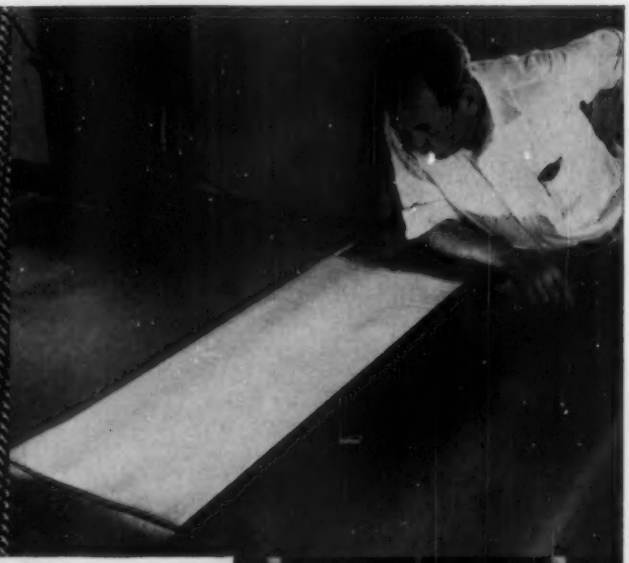

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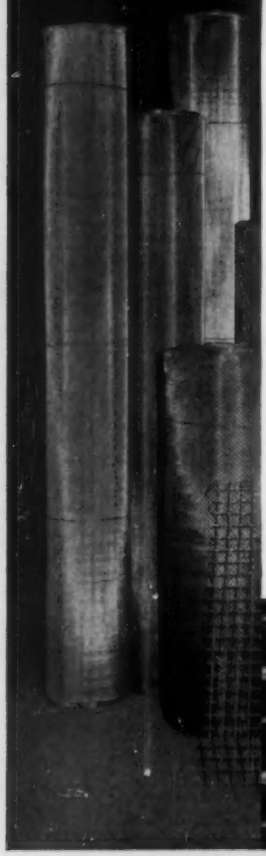
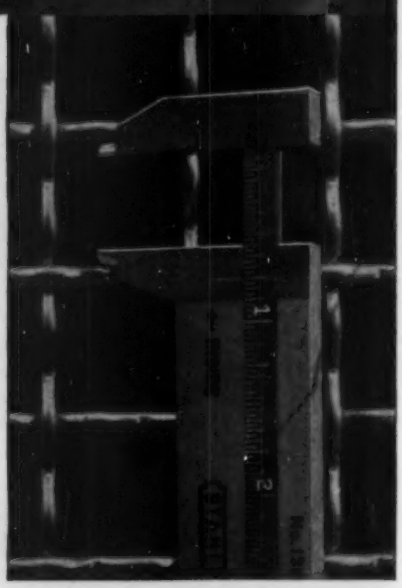
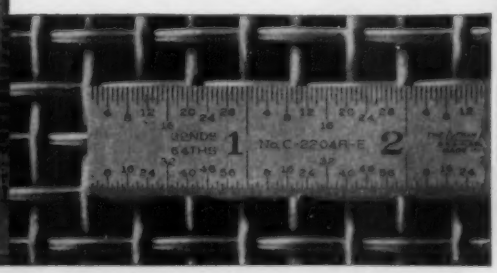
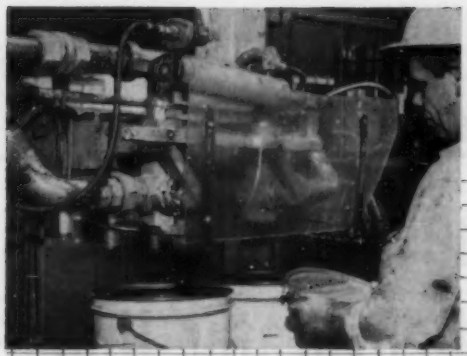
Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

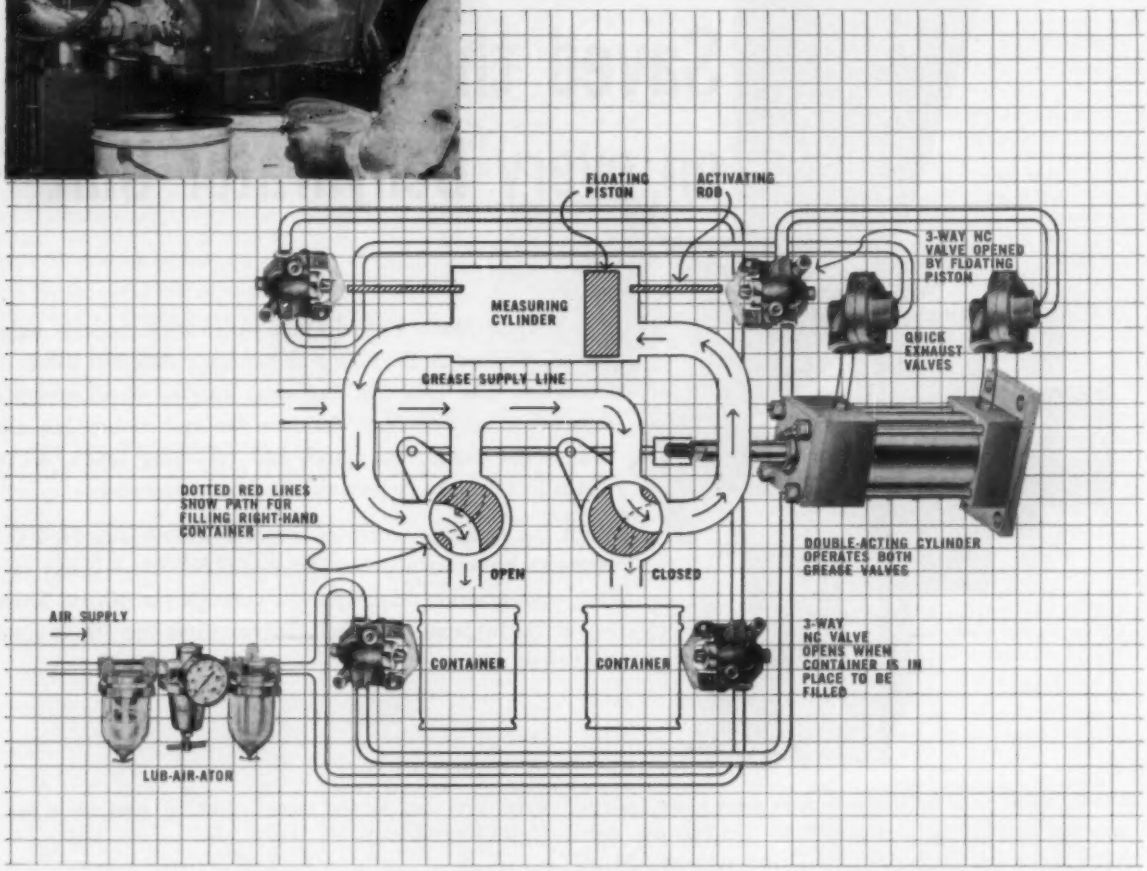








Here is an example of Schrader at work. Barrett Mfg. Co. of Houston, Texas, makes grease handling equipment for Mobil Oil's Brooklyn, N. Y., refinery. This machine fills 35 pound grease drums automatically accurately, 15 per minute! George Barrett, who designed and built this machine and other machines for Mobil, says: "My reputation for quality is too hard-won to risk by using some inferior line of air products."



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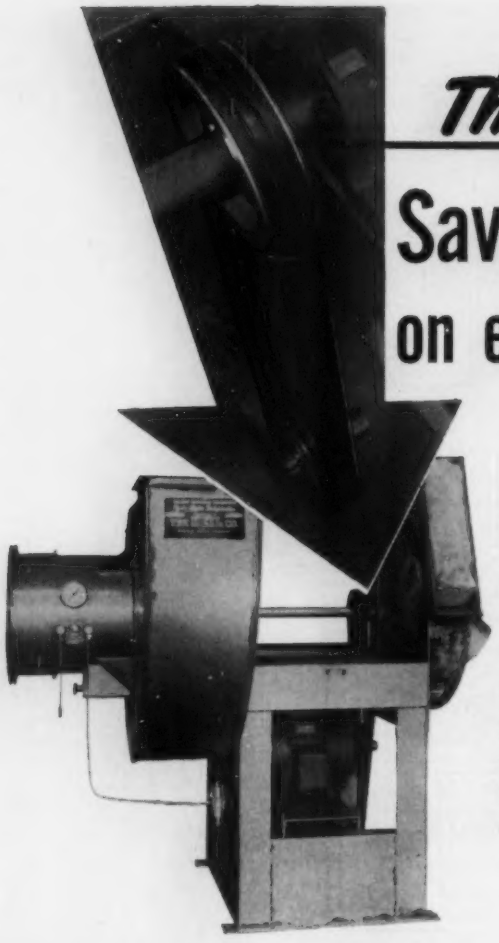

This New V-Belt Drive

Saved the Heil Co. $40 on every Dehydrator Unit

When Cyclo-Matic Dehydration Units were recently redesigned for greater flexibility in handling different kinds of materials, The Heil Co. engineers decided to incorporate separate motors to drive the main fan and cooling fan, the compressor pump, oil pump, and revolving drum, all of which had previously been driven from one motor.

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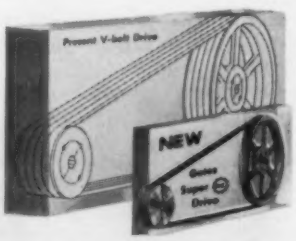
SAVED COST: On the original main drive alone, cost of conventional-type drive was $128.30. On the new main drive, Super HC High Capacity Drives cost only $88.26 — a saving of $40.04 on each main drive! While cost savings on auxiliary drives were not appreciable, additional benefits were reaped here through . . .

SPACE AND WEIGHT SAVINGS: Up to 62% saving in space, and as much as 32% saving in weight, have been realized over and over — not only by The Heil Co., but by hundreds of other manufacturers who have put Gates Super HC High Capacity V-Belt Drives on their products. You can do the same —just by contacting your Gates Representative.

AVAILABLE NATIONWIDE — Gates Super HC High Capacity V-Belt Drives are stocked in key industrial centers throughout the United States and Canada. You'll find your nearby Gates Representative listed in the Yellow Pages of your phone book. Ask him for your free copy of *The Modern Way To Design Multiple V-Belt Drives.*

The Gates Rubber Company, Denver, Colorado

Gates *World's Largest Maker of V-Belts*



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same hp capacity in smaller package

TPA540

Some Ideas

for your file of practical information on graph papers

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A graph can be defined as: "A picture of a collection of facts." Often, like that well known Chinese watercolor, a graph is worth a thousand words – or figures. There's no question that graphs speed up comprehension. In some cases, no other way exists to show the subtle interaction of statistics and data except by graph. It's no wonder that legions of engineers, architects, scientists and businessmen rely on graphs and charts to give them the complete information they need.

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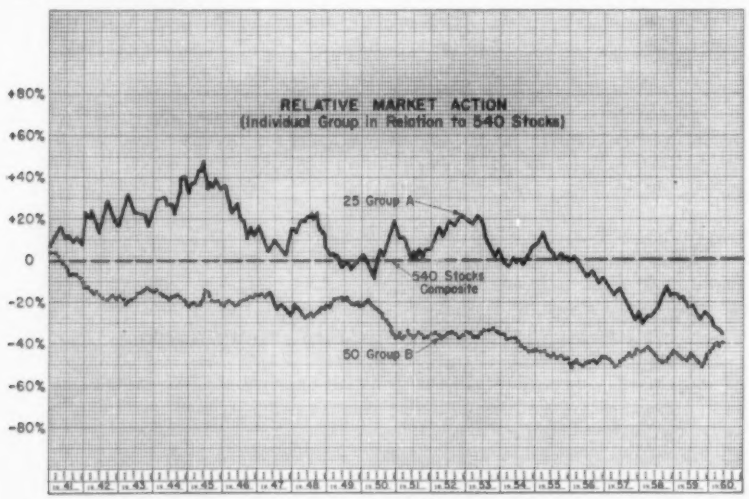

12,300 variables at a glance. Here's a typical stock market chart used to study relative market action. Center line is market behavior of 540 stocks over 20-year period. Two basic stock groups of 25 and 50 individual stocks, averaged, are plotted against market (figured at zero per cent). Resultant chart shows all-important slope of curve which – far more than gross increases – tells the story of the stocks' vitality. No list of statistics, no matter how exhaustive, could give the relative interactions shown here. This picture is possible only with a graph.

But if we don't have what you want – if we lose that 1000 to 1 bet – we'll gladly pay off by working with you to create exactly what you need. We've done this thousands of times for other customers. Just recently it was the U.S. Bureau of Standards. We worked with them to devise two new sheets for recording the complex heat reaction patterns of various insulating materials. These two sheets are already "standards" in the electrical industry.

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What *is* the graph paper that will do the best job for you? (Actually, there may be more than one – dozens perhaps.) We could answer that here, but we've already done so in a brand new edition of our famed K&E Graph Sheet Catalog. Not only does this catalog guide you in the

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We've printed an ample supply of this new catalog, and are prepared to send you your copy *free*. Just return the coupon below.

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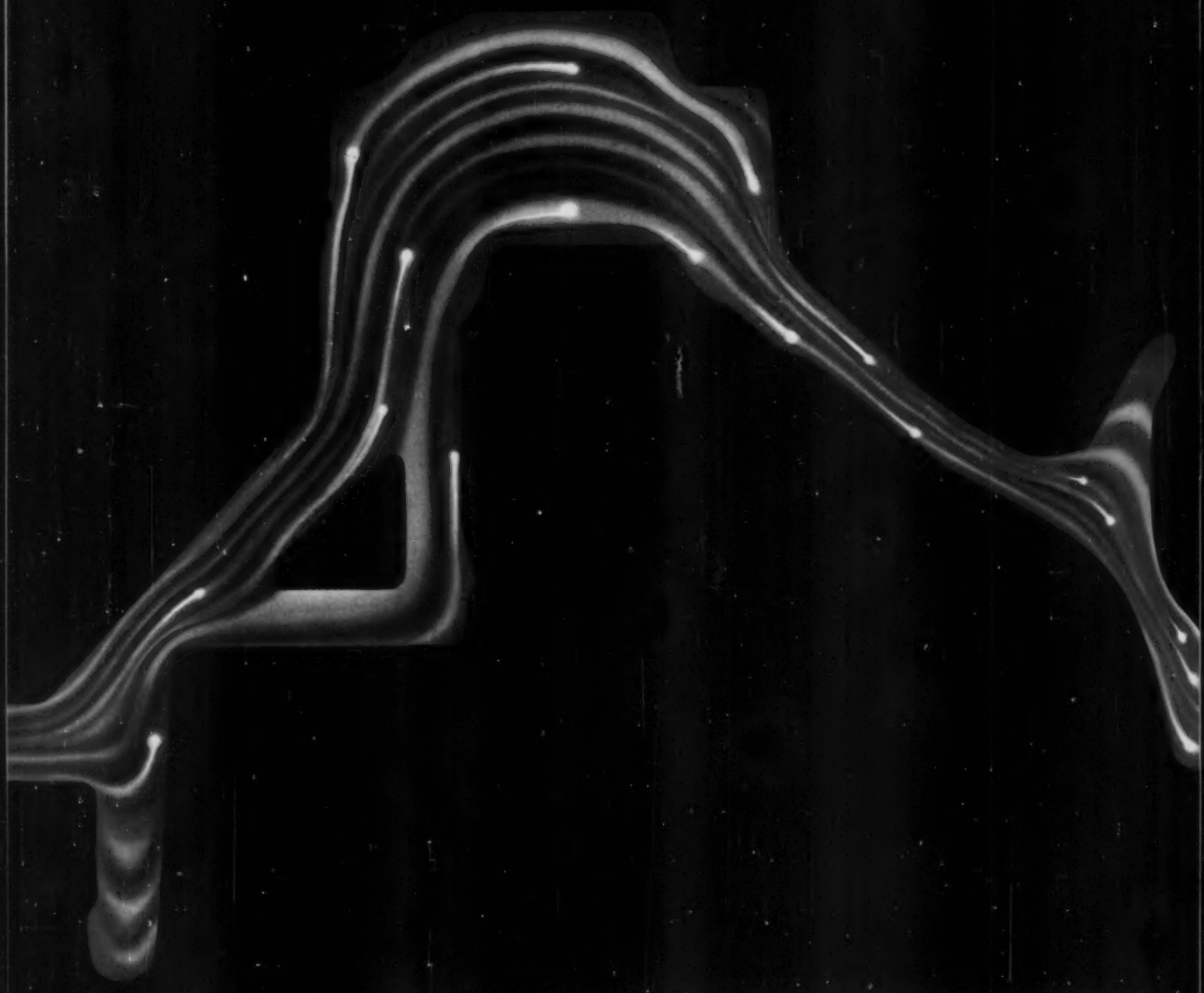

Liquid flow through a cross section of a Malleable differential carrier.

For Performance-Tested Dependability...Use Malleable

Molten metal flows evenly into all parts of the mold, then solidifies into pre-shaped parts with uniformly dependable properties throughout. Malleable iron castings will stand up under extremes of tension, impact, torsion, shear, fatigue, wear, heat, cold, and corrosion. They also offer maximum economy, are easy to work, and are versatile enough for parts ranging from a few ounces to hundreds of pounds.

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For details on Malleable's uniformity and reliability contact any company listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

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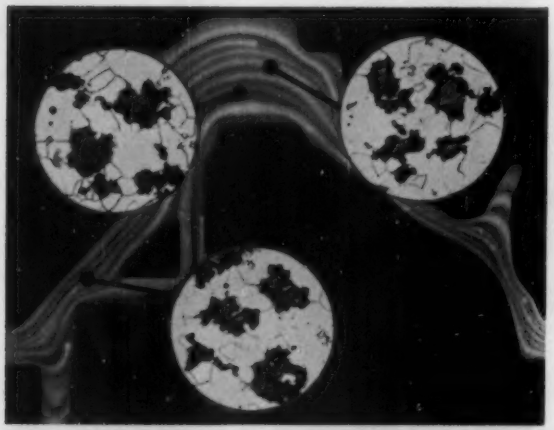
Uniformly Dependable All The Way Through!

Section a Malleable iron casting . . . check it under the microscope. You will find it shows a similar microstructure all the way through . . . and, therefore, gives you unvarying strength, toughness, and easy machinability.



Structural uniformity in a typical Malleable casting is seen in these micrographs from thick and thin, center and near-surface areas of the automotive differential carrier shown in the color illustration. Samples are magnified 100 times after 3% nital etch.

Uniformity Assures Design Versatility and Easy Machinability

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Free Assistance and Information

Any member of the Malleable Castings Council will be pleased to assist you in making engineering decisions for effective use of Malleable castings. For further information, call or write today to any of the companies listed below for *Data Unit No. 103 "Uniformity"*, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

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Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

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Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

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Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

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PRODUCT ENGINEERING HORIZONS

DECEMBER 5, 1960

ENGINEERING SLANG

The Eskimo, I am told, has totally different words to mean wind, little wind, big wind, north wind. This is supposedly a characteristic of a primitive or rudimentary language, not of the highly developed ones of Europe, from which ours is derived.

The Chinese language has no multi-syllable words, and each ideograph is actually a conventionalized picture meaning a particular thing. Thus, unless he knows each of several thousand ideographs, a Chinese cannot understand even simple scrolls. That is why the Chinese language is much more difficult than our 26-character alphabet and our polysyllabic words that make idea-transmission easy.

How wonderful it is to have a smart and modern language, particularly for an engineer! All the rest of the industrialized world finds our words the easiest to use, so ours is becoming the universal language of science and of engineering.

There is, of course, the little matter of our clumsy and antiquated system of measurement to which we and the originating English cling. We're perfectly agreeable to world standards for measurement—as long as they are ours. After all, aren't we the most automated, the most industrialized, so isn't it easier for them to shift than for us? Our language and our measurement are so very well worked out that others can save trouble by changing.

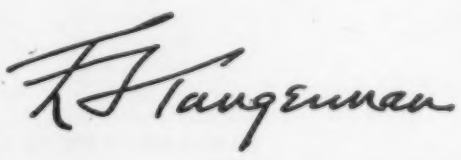
But can they? Are we really so sound? Take the engineering language as a case in point. Some of it shows the ravages of time. When we say "hob" do we mean a tool for cutting gear teeth or one for making a female die? When is a fixture not a jig, or an arbor not a mandrel? Is a burr a rough edge or the rotary file to remove it? And what is a file—a tool, a cabinet, a box of cards, a line of men?

Or let's consider our terminology for metals and plastics. The aluminum and magnesium alloys are clear enough; somewhere we quietly buried "duralumin" and tiptoed gently away. But the plastics are usually identified by tradenames even though we've forgotten "celluloid" and similar terms that were applied to early materials in this class. We've even almost dropped "iron" because most of our uses are for steel of one kind or another—really iron with precise quantities of impurities, one of which is carbon in combined form. Here we copy the Eskimo.

But consider man's oldest working metal, copper. What are "bronze" and "brass" but Eskimo words for special forms of copper? Architectural bronze nowadays is brass, as is hardware bronze; nickel silver contains no silver; aluminum bronze is more than 90% copper and has no tin content. And remember gilding metal, Muntz metal, German silver, phosphor bronze? Shouldn't these rather romantic and historic misnomers be quietly laid to rest? Wouldn't copper-123, or copper-H40 be a better, clearer system of nomenclature?

Isn't it time that some of our societies or standards groups surveyed this and similar archaic hangovers and came up with an understandable and efficient system?

If we are going to be, as we claim, the international apostles of clarity and efficiency, hadn't we better make sure our engineering language is clear and understandable?



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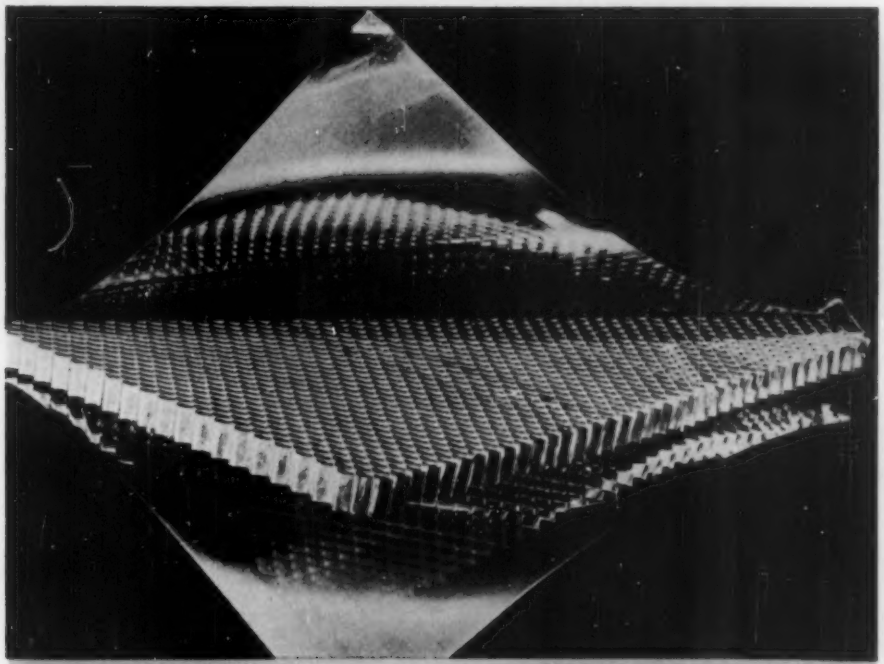
PRODUCT ENGINEERING

design guide for . . .

STAINLESS HONEYCOMB SANDWICH PANELS



Brazed honeycomb panels have become the most sophisticated structural elements in modern high-speed aircraft. Here is an introductory article that gives the basics of design, with emphasis on materials and practical details of construction.

D Y POTTER, *staff engineer*
Aeronca Manufacturing Corp
Middletown, Ohio

Shown above are the basic elements of a brazed stainless sandwich panel: upper facing, welded honeycomb core, and lower facing. Inserting a brazing alloy—in sheet or powder form—between these elements and brazing the sandwich in an inert gas atmosphere produces a structural element with one of the highest strength-weight ratios yet devised.

Between the concept of a structure based on such panels and the production of that structure lies a host of design problems—from materials selection to joint design. This introduction to brazed-sandwich-panel design discusses the most important of these problems and points the way to their solution.

How honeycomb sandwich panel works

The two key modes of loading in structures are axial loading and bending. In axial loading, the most serious situation is compression, rather than tension, since buckling can occur. If a thin plate is loaded in edgewise compression, the load to cause buckling is inversely proportional to the square of the column's length. Put lateral guides at the midpoint, and the critical load increases four times; put guides at the quarter points, the column is strengthened by a factor of 16. And so on.

When a honeycomb core is brazed to the thin plate, so many lateral guides are added that the effective column

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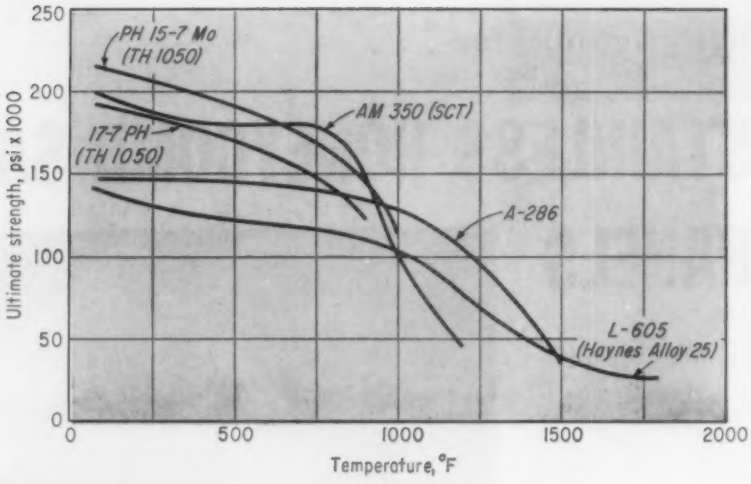
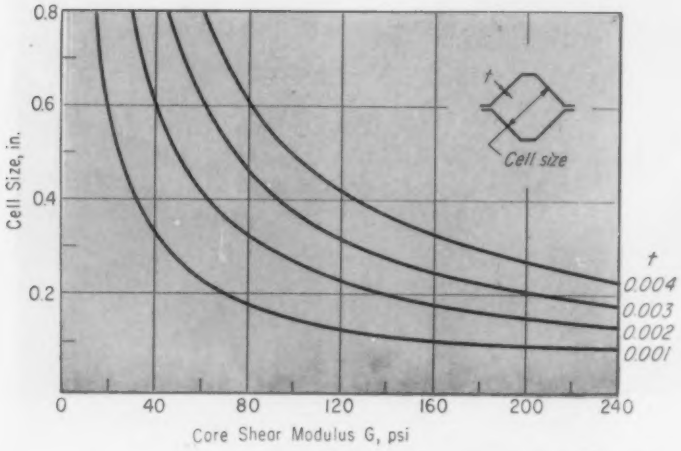
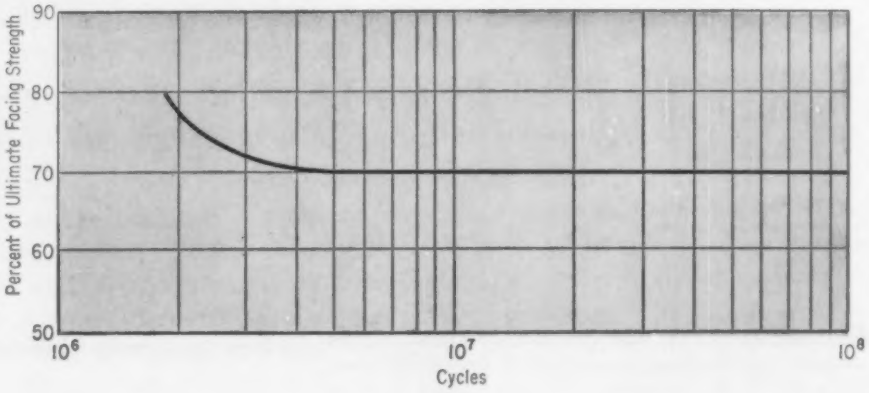


STRENGTH VS TEMPERATURE. Curves give comparison of three popular semi-austenitic steels for brazed honeycomb with two other superalloys used for very high-temperature performance. Other steels used include: Types 310, 321, and 347 stainless, Inconel, AM-355, 19-9 DX, Rene 41, M-242, and R-235.



SHEAR-MODULUS curves for unsupported core made from 17-7 PH alloy by Solar Aircraft Co are typical for the welded honeycomb types listed in Table II. Modulus curves shown here are for shear in the longitudinal direction—parallel to the plane of the nodal spotwelds.



FATIGUE STRESS of brazed 17-7 PH honeycomb panel should be held below 70% of ultimate facing strength, as shown by this fatigue run on a sandwich having 0.500-in.-thick, type 3-15 core brazed to 0.010-in.-thick facings. Room-temperature ultimate strength for 17-7 PH alloy averages about 200,000 psi (180,000 psi min.) in the TH 1050 condition.

length becomes very small and the force to cause buckling becomes very high. The plate then tends to fail only when the compressive yield strength of the material is approached. Two plates, or facings, are used (a) to protect the fragile core, and (b) to provide strength under bending loads. The net result is a new, composite column that gets much of its edgewise compressive strength from the increased radius of gyration ρ. Since critical load is directly proportional to ρ^3, such a design can be made highly efficient by choosing the proper combination of facing thickness and core-cell dimensions.

When panel is loaded in bending, core and brazed bond must be able to transmit shear from face to face. This fixes core-cell wall thickness and cell size.

Design equations

Because of the composite nature of brazed sandwich panels, special design equations must be devised. Most

TABLE I—BASIC DESIGN EQUATIONS FOR HONEYCOMB SANDWICH PANELS

Description	Equation	Nomenclature
PANEL BUCKLING under edge compression is quite similar to any column buckling (for which the equation is $P_{cr} = \pi^2 EI/l^2$) except that composite nature of sandwich makes the "EI" term more complex.	$P_{cr} = \dfrac{\pi^2 D}{l^2 + \pi^2 D/G_c c}$	P_{cr} — Critical edge load, lb/in. l — Length of panel, in. G_c — Core shear modulus, psi C — Core thickness, in. D — Panel bending stiffness, lb-in. $= \dfrac{Et_1 t_2 (h+c)^2}{4\lambda (h-c)}$ E — Facing modulus, psi t_1, t_2 — Facing thicknesses, in. h — Panel thickness, in. $\lambda = (1 - \mu^2)$ μ — Poisson's ratio
CORE SHEAR stresses are set up when sandwich panel is loaded normal to its surfaces. Facings, stabilized by core, can resist bending stresses, but have insufficient area to resist beam shear. Core must resist effort of loads to shear the beam. Allowable values of S_{sc} can be selected from Table III.	$S_{sc} = \dfrac{V}{bd}$	S_{sc} — Core shear stress, psi V — Max shear force in beam, lb d — Distance between facing centroids, in. b — Panel width, in.
CORE CRUSHING is caused by loads normal to the plane of the sandwich panel or beam, and is a local failure. Beam flexure set up by couples composed of in-plane loads can also cause core-crushing because the beam can curve enough to give these forces a normal, crushing component.	$S_{sc} = \left(\dfrac{2S_c^2}{E}\right)\left(\dfrac{t}{d}\right)$	S_{sc} — Core-crushing stress, psi S_c — Core compressive strength t — Min facing thickness, in. E — Facing modulus, psi d — Distance between facing centroids, in.
INTERCELL BUCKLING is a local failure condition characterized by wrinkling of the sandwich facing between the walls of the honeycomb core—the area where the facing is unsupported. Equation approximates the facing compressive stress that will cause this failure.	$S_{cr} = \left(\dfrac{E}{3}\right)\left(\dfrac{t}{R}\right)^{n/3}$	S_{cr} — Intercell buckling stress, psi R — Honeycomb-cell size, in. t — Min facing thickness, in. E — Facing modulus, psi
DEFLECTION of sandwich panel or beam depends on geometry of loading as well as a panel configuration and material constant. Equation is for quarter-point loading, a common condition. Equations for other conditions can be calculated. Deflection is usually limited to some percentage of span.	$w = \dfrac{5PL^3}{349\,Db} + \dfrac{PLc}{2(h+c)^2 G_c b}$	w — Center deflection, in. P — Total load, lb D — Panel bending stiffness, lb-in. (see "panel buckling" for equation) L — Support span, in. b — Beam width, in. c — Core thickness, in. h — Panel thickness, in. G_c — Core shear modulus, psi

of these deal with buckling loads since the panels are constructed from thin sheetmetal: hence elastic instability becomes the usual mode of failure. Equations have been derived, and verified experimentally, for a great variety of loading situations—particularly those found in airframe design. Table I (above) lists the most common design equations that cover the majority of design problems. Included are equations for core crushing under excessive local loads normal to the panel, as in flooring, and for beam deflection—often a limiting factor.

Materials and fabrication

The precipitation-hardenable stainless steels are the most commonly used metals for high-performance brazed sandwich panel—particularly where high operating temperatures are a problem. Among the desirable characteristics of these materials are the ease of forming the annealed material, ease of joining, and good corrosion resistance. High strength can be obtained by moderate-temperature (about 1000 F) aging treatments, or by refrigeration plus aging treatments.

Of these stainless steels, most emphasis in honeycomb panel has been given to 17-7 PH, its higher strength modification PH 15-7 Mo, and AM 350. Aging for the first two steels is usually done at 950 F or 1050 F, hence the temper designation following the alloy designator: 17-7 PH (TH 950) or 17-7 PH (TH 1050). AM 350 is usually hardened by subzero cooling and tempering at about 850 F. Resulting condition is termed SCT (subzero-cooled and tempered).

These semiaustenitic steels are compared on facing page with a fully austenitic type, A-286, and L-605, a cobalt-base alloy. Commonly called superalloys, A-286 and L-605 extend the usable upper temperature limit of brazed stainless sandwich from about 900 F to about 1800 F. All these alloys are commercially available as facing sheet stock and as core material.

Welded honeycomb core is produced in two principal ways. In one, a bundle of flat sheets of foil is built up. Each successive sheet is roll-spotwelded to the previous sheet at alternating points. Spacing between these weld points determines cell size, because the actual honeycomb is formed by pulling the top and bottom sheets apart. Thickness of the core is established by cutting the spot-

TABLE II—PROPERTIES OF STAINLESS HONEYCOMB CORE MATERIAL

(square-cell, welded core of PH 15-7 Mo, 17-7 PH, and AM 350 Alloys)

Core Type	Cell Size, in.	Foil Gage, in.	Density, lb/cu ft	Shear Strength, psi*
3-10	3/16	0.001	5.7	577
3-15	3/16	0.0015	8.4	944
3-20	3/16	0.002	11.2	1688
3-30	3/16	0.003	16.5	3685
3-40	3/16	0.004	22.0	6560
4-10	1/4	0.001	4.3	248
4-15	1/4	0.0015	6.2	516
4-20	1/4	0.002	8.3	924
4-30	1/4	0.003	12.5	2105

*Calculated from shear-strength equation presented in ANC-23 "Sandwich Construction for Aircraft," Vol II: $S_{cs} = 22.85 \times 10^6 w_c^2/(2w - w_c)$; where w_c is core density, w is core-material density.

TABLE III—TYPICAL PROPERTIES OF BRAZED HONEYCOMB PANELS

(At room temperature)

Brazing Alloy	Panel Description	Max Facing Stress (edgewise compression), psi	Max Core Shear Stress, psi	Max Oper. Temp, °F
Ag-Mn	17-7 PH Stainless, condition TH 1050; type 3-15 core, 0.50-in. thick, with 0.010-in. facings	186,080	580	800
Ag-Mn-Li	17-7 PH Stainless, condition TH 1050; Type 3-15 core 0.50 in. thick, with 0.010 in. facings	165,000	670	800
Ag-Cu-Li	17-7 PH Stainless, condition TH 1050; Type 3-15 core 0.50 in. thick, with 0.008 in. facings	185,200	773	80
Ni-base	A 286 alloy; Type 4-30 core 0.50 in. thick, with 0.018 in. facings	138,850	704	1350
Ni-base	L-605 (Co-alloy); Type 4-20 core 0.50 in. thick, with 0.025 in. facings	120,500	490	1800

welded bundle before it is expanded. To get the right cell shape, the honeycomb slice is overexpanded a precise amount to allow for springback. In the second method, the sheets are preformed in special corrugating machines, and welded layer-by-layer where the corrugations meet. Physical constants for the welded core—required for some of the design equations of Table I on preceding page—are given in shear-modulus curves (p 68) and Table II above.

Forming of the sandwich structure components follows conventional steel-die practice to ensure parts with closely controlled dimensions. Tolerances of ±0.003 in. are required to ensure proper fit for all brazed joints. Precise core thickness is usually obtained by machining the as-received core blanket in the unstabilized condition. Cemented to a metal plate, the blanket can be cut without leaving burrs via several machining processes. Most common are high-speed disk-cutting and electromechanical machining. After shaping, facings and cores are chemically cleaned to remove oxide or other impurities before brazing.

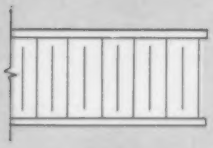
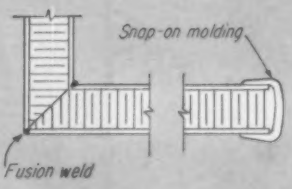
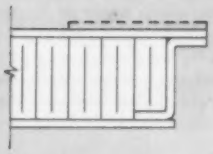
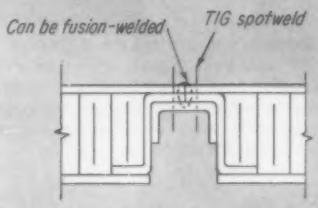
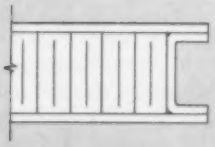
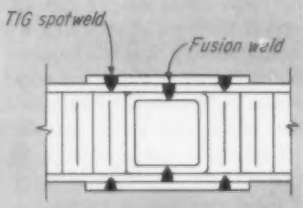
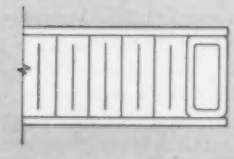
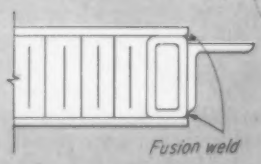
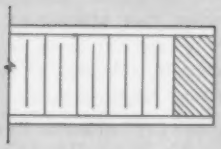
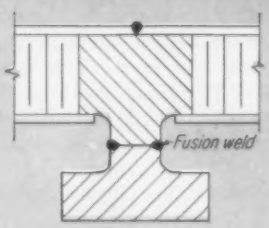
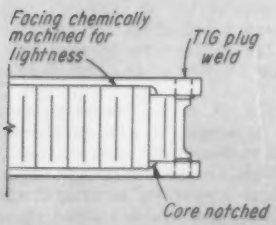
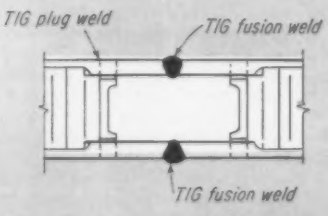
Silver brazing alloys are usually in the form of 0.002-in.-thick foil, cleaned carefully to remove tarnish or rolling lubricants. Other alloys, supplied in powder form, are dusted on the facings after spraying them with an acrylic binder that decomposes early in the brazing cycle. Brazing is done in a protective argon atmosphere. Heat sources for brazing include furnaces, electric blanket devices, quartz tube lamps, and salt baths—with furnace heating predominant at present. To ensure intimate contact of all brazed surfaces, a graphite fixture—either flat or curved—is employed, usually under light gas pressure. When high strengths are required, the heat treatment and aging processes described above are performed on the brazed panels. Typical properties of the final honeycomb panel, using various alloys and brazing materials, are shown in Table III and the fatigue curve on p 68. More detailed property data can be obtained from most brazed-panel manufacturers.

Fastening and joining

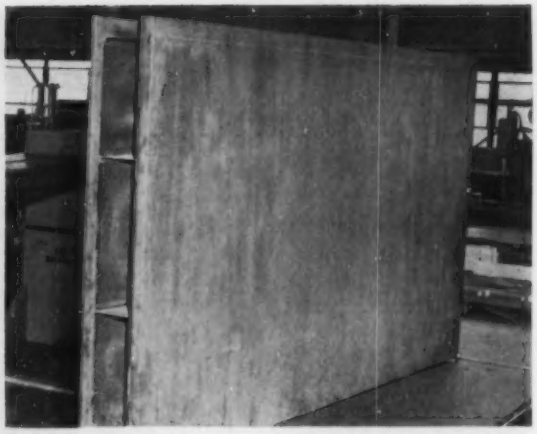
A honeycomb panel is seldom loaded as a free beam or plate. It is usually fastened to other panels to form a structure that carries both distributed and concentrated loads. These loads are distributed from panel to panel through edge members especially designed to do this job, yet be producible. If the edge member is too complicated or expensive to be brazed, then the advantage of sandwich construction is lost. Table IV shows six basic edge treatments along with six typical joints that utilize them. Both simple and complex edges are shown. The last edge treatment—tabbed and slotted—uses tungsten inert gas (TIG) plug- and spot-welding. End plates have tabs that fit into slots in the facings. Although the designs and the information shown in Table IV are typical, they represent only a

TABLE IV—DETAILS FOR HONEYCOMB SANDWICH PANEL CONSTRUCTION

(Typical assemblies at right use basic edge treatments at left)

Edge Treatments	Remarks	Assembly Details
	**PLAIN** edge leaves the core exposed, usually because the edge will be hidden at assembly (as shown at right), or because the edge does not require stiffening. This latter case is unusual because core materials are thin and easily damaged.	
	**Z-EDGE** gives some support, especially against shear loading, but is not recommended when edge loading is unsymmetrical. Additional stiffness can be provided by doubler plates added when panel is made (left) or when panels are assembled (right). Doublers can be external (dashed lines) or internal (requiring core to be notched).	
	**CHANNEL** edge stiffens edge against unsymmetrical loading, as often occurs in panels heavily loaded in edgewise compression. Joining legs of channels by fusion welding (right) maintains thickness of panel structure and provides passage for fluids, control cables or wiring. Doublers can be added externally by TIG spot welding (as shown) or internally when panels are made.	
	**HOLLOW** edge, such as thin-walled tube, can be specified where a lightweight flush edge is desired, or where the panel must be attached to open framing (right). Hollow edge facilitates attachment of hardware such as hinges, latches, seals, etc.	
	**SOLID** edges are essential when loads are concentrated or when a specially shaped edge is needed to match another part of the structure (right). Special features can be cast into a solid edge, such as the hinge points for an aircraft aileron. Solid edges can also be potted, using cure-in-place plastics of either the rigid, semirigid, or flexible type.	
	**TABBED** edge is lightweight type of solid edge used where high strength-weight-ratio is essential. Spaced tabs on the edge plate pass through drilled holes on the faces. Assembly is by TIG plug-welding. Thickness of facings and edge plates in region of weld must be greater than nominal to offset annealing effect on heat-treated materials. Thickened contour is achieved by chemical milling, and increases cost considerably.	

SPEED-BRAKE ON NAVY ATTACK PLANE is made of curved sandwich panel, nickel-brazed from A-286 alloy. Super-alloy is required because braking surface opens into jet-engine exhaust and surface temperature exceeds 1000 F. Linkage-stiffening structure is fusion-welded on bottom facing of sandwich before brazing.



PROTOTYPE WING-BOX FOR HIGH-SPEED BOMBER is built up from two silver-brazed sandwich panels of PH 15-7 Mo alloy. Panels, each 5 x 10 ft, have small angles brazed in place on one face for attachment to four corrugated ribs by spotwelding. U-shaped edges are fusion-welded to panels before wing-box is assembled.

few of many configurations now in use, and are presented to suggest methods of attacking a given edge problem.

Local stiffening is often required to support loads concentrated at points within the panel edges. In these cases, an area of higher density honeycomb core is inserted where needed and spliced to the surrounding core by spot-welding. Solid metal inserts can also be specified, but add considerably to panel weight. A simpler method is to stiffen both faces locally with external doubler plates brazed in place or to use facings chemically milled to give stiffened edges. Tubes are easily passed through perpendicular to the panel via brazed-in-place collars or coupling; running tubes through the honeycomb in the plane of the sandwich is more difficult and costly, but can be done.

Quality control

Inspection of brazed honeycomb panels is difficult because the joints are inaccessible. Accordingly, a combination of destructive and nondestructive tests is usually employed.

Destructive tests include checks on the original materials before brazing and six basic tests on the composite sandwich structure in the form of test specimens. These include: edgewise and flatwise compression, flatwise tension, core shear strength, flexure, peel, and fatigue. Some or all of these may be used, depending on safety problems involved.

Nondestructive testing includes, in addition to expert visual inspection of all external surfaces, the following three methods: X-ray (radiographic and fluoroscopic), ultrasonic, and heat-sensitive coatings. This last technique is relatively new and depends on the thermal-conductance characteristics of the panel for its effectiveness (see *PE—Feb 15 '60, p 82*). X-ray and ultrasonics are most common, though still quite slow and expensive—either in equipment costs or processing costs. Heat-sensitive coatings show great promise for high-speed, low-cost inspection. In all the methods, precise standards of comparison are a must.

Cost of honeycomb sandwich

Brazed honeycomb panels are expensive as composite engineering materials go, but have been dropping in price steadily. Current cost for 1-in.-thick flat panel of 17-7 PH stainless with normal edge attachments and type 3-15 core runs $150 to $200 per sq ft. In 1956, this range was about $225 to $300. By 1963, this is expected to be about $50 to $75 or lower. Six factors are operating to bring this cost down: lower core cost, much lower rejection rates, simpler tooling for brazing, increasing use of fast heat methods, smaller quantities of inert gases required, and development of automatic inspection techniques. Cost of curved and tapered panels is expected to be favorably influenced by these same factors but, because of forming costs, they will remain higher than flat-panel cost.

For REPRINT of above article, just check P71 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: For more on sandwich panel construction, materials, and fabrication details, see:

18 Ways to Join Honeycomb Panels, Mid-Sep '60, p 348—Guide to selection among mid-panel and panel-rib joints, spar-panel intersections, and edge-member attachments.

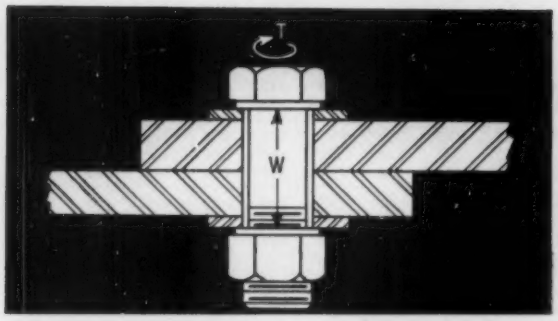
Designing Brazed Joints for 1000 F and Above, Aug 1 '60, p 40—Roundup tells how high-temperature brazing works, when to specify it, how to select the right materials, and procedure to get design started.

Flexure Limits for Foamed Plastic Sandwich Panels, Apr 13 '59, p 69—Whether testing panels or designing with them, how they behave under flexure is important. Authors show what causes failure and how to design safely.

Sandwich Panel Adhesives, May 26, '58, p 56—In this article, concluding a 3-part series on sandwich materials, the 14 most widely specified adhesives are described and compared. First part, Jan 20 '58, p 70, covered core materials; second part, Apr 28 '58, p 80, compared facing materials.

Chemical Milling, Feb 3 '58, p 50—Covers an industrial etching technique now developed to give large-scale production of parts difficult to handle by other methods.

Stainless Steels for High Temperatures, Apr '57, p 135—Article details mechanical properties, structural stability, and fabrication methods for five austenitic and three martensitic alloys developed for high-performance aircraft.



WHAT TORQUE TO TENSION PLATED BOLTS?

For a given torque, tension will vary inversely with the coefficient of friction—which is affected by whether plating goes on bolt, nut or washer.

VERNON STIMPEL, *chief fastener engineer, MacLean-Fogg Lock Nut Co, Chicago*

Bolts, nuts and washers plated with cadmium or zinc are increasing in popularity because of their "eye appeal" and resistence to corrosion. Plating, however, affects the coefficient of friction, and this must be allowed for when figuring proper bolt torque for the desired tension.

It is generally agreed that only about 10% of the applied tightening torque of a threaded fastener is translated into actual tension. Of the remainder, 40% is lost in friction on the thread flanks and 50% in friction at the bearing surface.

The accepted empirical approximation for the torque-tension relationship is:

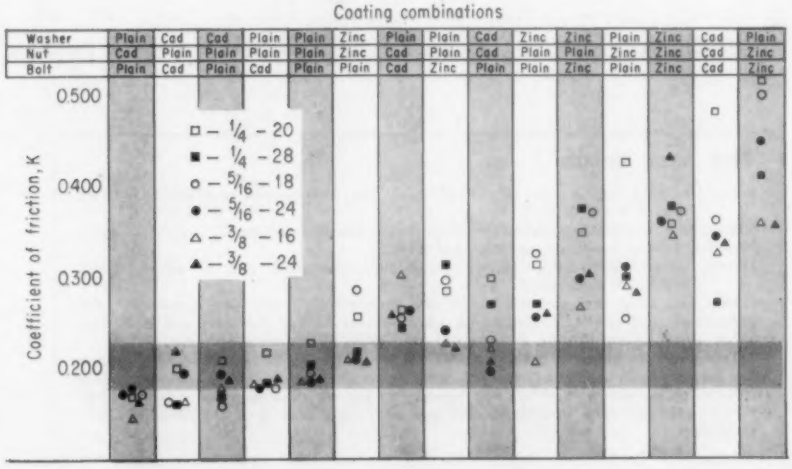
$$T = \frac{KDW}{12}$$

Where T = torque, lb-ft
K = coefficient of friction
W = bolt tension, lb
D = nominal bolt diameter, in.

Normally, 0.20 is used as an average coefficient of friction for clean, unplated bolts, nuts and washers. This has been verified by many experimenters.

Test results

To determine the effect of cadmium and zinc plating, 36 specimens were tested for each of three sizes and 15 combinations tabulated on next two pages. The results show that for plain (unplated) steel combinations the coefficient of friction is the usually accepted 0.20. They also show that in the same-size bolts, when plated, the


Coating combinations
Washer Plain Cad Cad Plain Plain Zinc Plain Plain Cad Zinc Zinc Plain Zinc Cad Plain
Nut Cad Plain Plain Plain Plain Zinc Cad Plain Cad Plain Plain Zinc Zinc Cad Zinc
Bolt Plain Cad Plain Cad Plain Plain Cad Zinc Plain Plain Zinc Plain Zinc Cad Zinc
0.500
0.400
0.300
0.200
Coefficient of friction, K
□ – 1/4 – 20
■ – 1/4 – 28
○ – 5/16 – 18
● – 5/16 – 24
△ – 3/8 – 16
▲ – 3/8 – 24

COEFFICIENTS OF FRICTION were calculated from these test results. Each point represents an average of 36 specimens tested.

REPRINTED—Circle P70, inside back cover

Seating Torque Lb-ft	Bolt Nut Washer	Plain Plain Plain	Cad Plain Plain	Plain Cad Plain	Plain Plain Cad	Cad Cad Plain	Plain Cad Cad	Cad Plain Cad	Cad Cad Cad	Zinc Plain Plain	Plain Zinc Plain	Plain Plain Zinc	Zinc Zinc Plain	Plain Zinc Zinc	Zinc Plain Zinc	Zinc Zinc Zinc
		1/4–20 BOLT	**TENSILE LOADS DEVELOPED, LB**													
2	Min	350	325	500	325	250	250	350	150	250	200	250	150	300	200	200
	Max	400	400	600	400	450	300	450	200	350	250	350	250	400	250	350
	Ave	**366**	**379**	**550**	**379**	**308**	**270**	**387**	**178**	**300**	**216**	**283**	**197**	**367**	**233**	**287**
4	Min	725	700	1000	750	650	575	850	325	550	400	500	275	625	400	500
	Max	850	900	1200	950	900	700	950	400	725	525	800	500	900	625	700
	Ave	**800**	**808**	**1133**	**850**	**700**	**629**	**883**	**370**	**658**	**454**	**587**	**362**	**762**	**508**	**562**
6	Min	1100	1300	1500	1300	1050	950	1400	550	900	575	800	425	975	600	550
	Max	1450	1500	1900	1650	1450	1200	1700	650	1200	700	1225	800	1450	1125	1050
	Ave	**1304**	**1391**	**1783**	**1441**	**1140**	**1016**	**1537**	**700**	**1062**	**679**	**929**	**554**	**1196**	**941**	**829**
8	Min	1450	1750	2000	1800	1400	1250	1950	750	1200	800	1100	550	1275	850	725
	Max	2000	2150	2500	2300	1900	1650	2275	900	1600	1000	1550	975	1725	1550	1350
	Ave	**1791**	**1950**	**2325**	**2008**	**1625**	**1370**	**2145**	**829**	**1446**	**896**	**1246**	**708**	**1500**	**1191**	**1054**
10	Min	2000	2200	2650	2400	1800	1675	2600	1000	1675	1000	1450	750	1550	1200	950
	Max	2500	2750	3000	2800	2450	2000	2950	1200	2000	1350	2000	1325	2150	1975	1650
	Ave	**2358**	**2500**	**2805**	**2641**	**2000**	**1808**	**2830**	**1120**	**1866**	**1191**	**1683**	**960**	**1870**	**1546**	**1291**
		1/4–28 BOLT														
2	Min	400	400	400	450	200	300	450	250	250	300	300	200	350	200	200
	Max	450	500	500	500	400	350	600	500	300	400	400	250	550	300	350
	Ave	**416**	**441**	**441**	**475**	**325**	**316**	**533**	**333**	**283**	**333**	**316**	**225**	**425**	**250**	**258**
4	Min	900	1000	950	1000	500	600	1250	450	550	600	600	400	700	400	400
	Max	1050	1100	1300	1400	1000	750	1350	900	800	700	900	500	1200	550	700
	Ave	**983**	**1033**	**1083**	**1183**	**766**	**675**	**1291**	**683**	**650**	**650**	**700**	**475**	**883**	**483**	**525**
6	Min	1450	1600	1500	1500	850	900	1850	750	850	900	1000	550	1150	600	600
	Max	1750	1700	2000	2000	1500	1150	2100	1500	1200	1050	1400	800	1700	900	1000
	Ave	**1541**	**1641**	**1775**	**1883**	**1225**	**1083**	**2000**	**1091**	**1016**	**991**	**1133**	**725**	**1333**	**758**	**783**
8	Min	1750	2150	2050	2150	1150	1300	2550	1050	1100	1050	1300	800	1500	950	800
	Max	2150	2500	2650	2700	2150	1550	2800	1950	1400	1350	1800	1150	2050	1250	1250
	Ave	**1825**	**2275**	**2425**	**2525**	**1741**	**1466**	**2675**	**1566**	**1266**	**1250**	**1550**	**966**	**1708**	**1041**	**1000**
10	Min	2100	2550	2600	2550	1450	1750	2800	1400	1300	1550	1700	1000	1900	1200	1000
	Max	2600	2900	2800	2700	2650	2100	2800	2400	1600	1700	2150	1400	2500	1450	1500
	Ave	**2400**	**2700**	**2725**	**2625**	**2175**	**1925**	**2800**	**1908**	**1458**	**1600**	**1891**	**1208**	**2125**	**1300**	**1225**
		5/16–18 BOLT														
3	Min	475	500	625	550	350	400	550	250	275	350	275	200	350	250	250
	Max	575	600	700	650	425	500	725	300	250	550	350	250	425	350	400
	Ave	**516**	**550**	**660**	**595**	**395**	**490**	**610**	**280**	**310**	**410**	**305**	**230**	**390**	**285**	**320**
6	Min	115	1150	1400	1250	850	850	1300	550	675	700	650	400	700	500	550
	Max	1200	1500	1750	1600	925	1050	1625	675	900	1300	800	600	825	650	875
	Ave	**1170**	**1315**	**1540**	**1400**	**900**	**940**	**1410**	**620**	**775**	**925**	**715**	**470**	**790**	**575**	**645**
9	Min	1750	1675	1875	1923	1325	1350	1950	900	1050	1050	1000	600	1050	800	850
	Max	1900	2250	2400	2250	1500	1600	2550	1050	1425	2000	1175	800	1400	1000	1200
	Ave	**1820**	**1920**	**2090**	**2100**	**1430**	**1490**	**2180**	**990**	**1250**	**1380**	**1100**	**700**	**1220**	**900**	**945**
12	Min	2400	2250	2800	2300	1750	1850	2675	1200	1450	1500	1350	800	1450	1100	1050
	Max	2600	3000	3750	3150	2000	2250	3500	1500	1950	2800	1600	1050	1875	1500	1600
	Ave	**2466**	**2683**	**3191**	**2925**	**1891**	**2050**	**3008**	**1383**	**1729**	**1900**	**1516**	**941**	**1633**	**1291**	**1225**
15	Min	2950	2800	3425	3600	2250	2400	3450	1650	1850	1900	1800	1000	1850	1500	1350
	Max	3150	3700	4600	4100	2500	2800	4200	1950	2500	3600	2025	1200	2300	1850	1900
	Ave	**3041**	**3330**	**3960**	**3810**	**2400**	**3670**	**3800**	**1790**	**2225**	**2530**	**1920**	**1130**	**2110**	**1670**	**1515**

The test setup

Bolts: Hex-head cap screws of C1018 steel, not heat-treated, equivalent to SAE Grade 2 or ASTM 307.

Nuts: Cold-forged, finished and double-chamfered; made of C1108 steel.

Washers: Type B regular as per ASA B27.2-1958.

Plating: Commercial quality cadmium and electro-deposited zinc of approximately 0.000,15 in. thickness.

Nuts and bolts were checked for fit with standard plug and ring gages. For the plain steel combinations, no additional lubricant was added. The nuts and bolts had either residual oils remaining, or some rust preventive. The washers were dry.

Tests were conducted on a Skidmore-Wilhem torque-tension fixture, which was checked for accuracy with a Tinius-Olson tensile-testing machine. The fixture checked within 0.008% of the tensile machine, and because of this all readings were taken directly. Torque wrenches used were Sturtevant type in ranges from 0 to 25 lb-in. up to 0 to 50 lb-ft.

coefficient of friction varies from 0.14 to 0.52, depending upon conditions and combinations used. This indicates that for cadmium and zinc combinations different coefficients of friction should be used to obtain the proper tensile load. These can be obtained from graph, or calculated from table.

The graph shows the average coefficient of friction at all load points for each size and combination tested.

Seating Torque Lb-ft	Bolt Nut Washer	5/16–24 BOLTS — TENSILE LOADS DEVELOPED, LB														
		Plain Plain Plain	Cad Plain Plain	Plain Cad Plain	Plain Plain Cad	Cad Cad Plain	Plain Cad Cad	Cad Plain Cad	Cad Cad Cad	Zinc Plain Plain	Plain Zinc Plain	Plain Plain Zinc	Zinc Zinc Plain	Plain Zinc Zinc	Zinc Plain Zinc	Zinc Zinc Zinc
3	Min	550	450	600	450	300	400	400	250	350	300	300	200	450	300	250
	Max	600	650	650	550	450	600	550	400	450	450	500	350	600	400	400
	Ave	**558**	**541**	**566**	**483**	**383**	**500**	**483**	**316**	**400**	**385**	**391**	**266**	**541**	**350**	**325**
6	Min	1150	1150	1000	1000	750	1000	1000	500	900	600	700	350	1000	700	500
	Max	1200	1600	1500	1300	1000	1350	1300	850	1050	850	1150	700	1300	950	800
	Ave	**1241**	**1283**	**1266**	**1175**	**891**	**1208**	**1150**	**658**	**950**	**750**	**866**	**533**	**1166**	**783**	**650**
9	Min	1800	1800	1600	1800	1150	1350	1650	900	1400	900	1150	550	1500	1100	850
	Max	2150	2500	2250	2000	1650	2100	2100	1250	1600	1150	1700	1000	2000	1500	1200
	Ave	**2000**	**2133**	**1991**	**1925**	**1358**	**1933**	**1875**	**1041**	**1508**	**1050**	**1366**	**791**	**1608**	**1225**	**966**
12	Min	2400	2300	2400	2500	1550	2200	2250	1200	1900	1400	1600	800	1800	1500	1050
	Max	2850	3200	2900	2750	2200	2700	3000	1700	2200	1700	2450	1300	2700	2000	1600
	Ave	**2675**	**2591**	**2775**	**2683**	**1800**	**2441**	**2641**	**1400**	**2083**	**1525**	**1891**	**1033**	**2250**	**1638**	**1266**
15	Min	3150	2950	3000	3150	2000	2700	2850	1700	2450	1750	2100	1100	2300	1900	1400
	Max	3700	3950	4100	3650	2900	3600	3800	2200	2900	2600	3100	1550	3050	2350	1900
	Ave	**3356**	**3308**	**3466**	**3466**	**2283**	**3133**	**3350**	**1875**	**2633**	**2033**	**2416**	**1291**	**2750**	**2033**	**1591**
		3/8–16														
5	Min	700	750	900	800	350	600	800	350	500	500	500	400	550	500	350
	Max	780	900	1050	950	550	1000	1000	500	750	600	800	600	900	600	500
	Ave	**766**	**825**	**1008**	**900**	**475**	**700**	**891**	**450**	**625**	**541**	**683**	**450**	**733**	**525**	**441**
10	Min	1650	1800	2050	1800	800	1300	2000	800	1100	1000	1200	700	1100	950	800
	Max	1900	2000	2300	2150	1150	1950	2350	1100	1800	1400	1750	1000	1800	1500	1050
	Ave	**1758**	**1988**	**2191**	**1991**	**966**	**1458**	**2116**	**950**	**1391**	**1108**	**1408**	**869**	**1591**	**1250**	**883**
15	Min	2550	2850	3000	3000	1500	2000	3250	1450	1800	1550	2000	1150	1700	1550	1250
	Max	2950	3150	3850	3500	2100	2300	3700	1900	2750	2000	2850	1550	2850	2350	1600
	Ave	**2733**	**3008**	**3425**	**3233**	**1675**	**2166**	**3416**	**1583**	**2191**	**1716**	**2400**	**1323**	**2325**	**1950**	**1416**
20	Min	3400	3950	4100	4000	2000	2750	4500	1800	2500	2000	2700	1650	2350	2250	1750
	Max	3950	4350	5000	5200	2850	3100	5100	2600	3700	2600	4000	2075	4100	3000	2150
	Ave	**3650**	**4141**	**4633**	**4508**	**2308**	**2875**	**4733**	**2118**	**2991**	**2291**	**3250**	**1832**	**3275**	**2558**	**1966**
25	Min	4150	4800	5150	4950	2500	3100	5700	2300	3150	2500	3300	2325	3550	2900	2300
	Max	4950	5400	5900	5200	3500	4000	6200	2800	4650	3250	4900	2750	4500	3750	2750
	Ave	**4466**	**5050**	**5691**	**5575**	**2883**	**3725**	**5925**	**2600**	**3883**	**2891**	**4058**	**2439**	**3933**	**3191**	**2508**
		3/8–24														
5	Min	700	700	600	650	400	600	600	300	350	450	450	350	650	350	250
	Max	850	1050	950	900	600	800	800	550	750	850	600	500	900	600	400
	Ave	**791**	**925**	**800**	**766**	**508**	**675**	**675**	**466**	**566**	**550**	**533**	**422**	**750**	**483**	**316**
10	Min	1450	1850	1500	1450	900	1250	1250	850	1250	950	1000	750	1250	700	650
	Max	1800	2400	2250	2000	1600	1600	1900	1130	1800	1400	1450	1050	2000	1250	850
	Ave	**1683**	**2066**	**1916**	**1683**	**1233**	**1475**	**1450**	**1016**	**1458**	**1118**	**1160**	**875**	**1658**	**1816**	**725**
18	Min	2500	2700	2350	2400	1300	2000	1700	1300	1900	1550	1600	1200	1950	1450	1100
	Max	2700	3700	3450	3100	2500	2500	2700	1700	2650	1900	2400	1550	3000	1950	1500
	Ave	**2625**	**3250**	**2933**	**2725**	**1925**	**2318**	**2141**	**1558**	**2308**	**1775**	**1350**	**1348**	**2491**	**1625**	**1250**
20	Min	3350	3500	3250	3100	1900	2750	2250	1700	2650	2150	2150	1700	2500	1850	1400
	Max	3700	4900	4750	4300	3450	3500	4000	2400	3550	2600	2800	2000	3800	2600	1950
	Ave	**3518**	**4200**	**3991**	**3850**	**2618**	**3118**	**2966**	**2150**	**3216**	**2333**	**2441**	**1859**	**3241**	**2208**	**1633**
25	Min	4150	4600	4000	4200	2500	3700	2750	2300	3200	2500	2950	2300	2950	2300	1700
	Max	4900	6200	5800	5600	4400	4300	5200	2850	4600	3600	3600	2700	4600	3200	2400
	Ave	**4458**	**5258**	**4866**	**5116**	**3250**	**4008**	**3733**	**2700**	**3900**	**3018**	**3066**	**2500**	**3900**	**2733**	**2175**

E.g. the ¼-28 plain bolt-nut-washer combination gave an average friction coefficient of 0.205 for all 36 specimens tested. These could be used for fast calculation of required torque.

The table gives minimum, maximum and average tensile load developed for each of several wrench-torque settings. The average figures are for 36 specimens of each combination, and this is the figure that should be considered as the true tensile load developed from the particular wrench-torque setting. To use this table, locate the desired tension and work backward to get the necessary torque setting. For example, if a ¼-20 zinc bolt-nut-washer unit requires approximately 300-lb tension you look in the ¼-20 portion of the bolt table for the average tensile load nearest to 300 lb. In this case it is 287 lb for a torque setting of 2 lb-ft. For a 4 lb-ft setting the corresponding load is 562 lb. By interpolating between 287 and 562, the correct torque for 300-lb tensile load is approximately 2.15 lb-ft.

This compares with 2.22 lb-ft obtained by formula and K from the graph on p 73.

For REPRINT of above article, just check P 70 on one of the Reader Service cards bound in this issue.

what every new engineer should know

Does someone you know—son, nephew, son of friends—need advice on his engineering career? If he does, hand him this.

P M ZALL
Director, Communication Research Center
Los Angeles State College

This capsule summary of opinion was compiled last summer from journals, interviews, and overheard (often over-heated) arguments. **It represents what old-timers feel the embryo engineer should know.** There are, of course, many things he cannot be told in public print; there are many points too specific to mention. There are also several questions so controversial they would require a book: big company vs small company; military business vs non-military business. Opinions summarized here, then, are representative generalities about the profession rather than about any particular field or person. They are based on **past** experience, and are the **personal opinions** of many different people in various engineering fields, various levels (top management, line engineers, draftsmen) and various industrial firms in the Los Angeles metropolitan area.

What is the most important thing every young engineer should have?

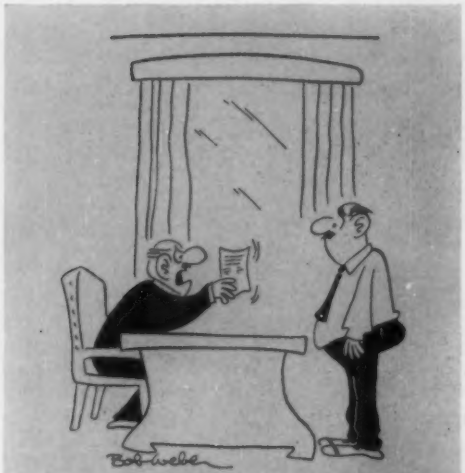
A proper attitude. This means having an interest in the company, the position, and the work. It also means being prepared to accept gracefully the fact that a beginning engineer must spend a lot of time on the drafting boards and also on "non-engineering" details such as administrative paperwork. And, though it may seem naive to mention, a proper attitude includes the realization that he cannot make as much money as his boss—at least not at the beginning. Most old-timers think a young man should try to get a "feel" for his professional situation; he should think in terms of a balance among budgets, schedules and performance. He should keep alive, alert, aware of what's going on around him and outside. And he should also try to learn where to begin a job and when to chop it off; over-engineering can be costly and wasteful. A desirable attitude, then, would include "know how," "know how to," and "know how much."

Must management be the goal of a successful engineering career?

Not necessarily. Many engineers have enjoyed a completely successful career without ever having sat behind a walnut desk. This is true even of many who have not had private incomes or married wealthy wives. Experts have long pointed out that managing and engineering require different skills and attitudes. Management, they say, requires skill in handling people and making quick decisions. Engineering requires belaboring a problem in search of an optimum solution which is at best a compromise. One observer pointed out that engineers can be

"Satisfied?"

distinguished from managers according to the card games they play during lunch hour. Engineers play bridge while managers prefer poker—emphasizing the cautious approach of the former and the dangerous living of the latter. But times are changing. Engineering training still hits hard on logical analysis: considering all variables, weighing the good and the bad, and compromising.



"According to this aptitude test you have been in the wrong job for 26 years."

Management training, on the other hand, has in the past emphasized glancing at the over-all picture from the corner of an eye, then shooting from the hip. But today engineering techniques are being applied to management more and more. The enviable success of Ramo and Wooldridge in this area has stimulated study and emulation. Operations Research is establishing a managerial technology of increasingly significant economic import. Nevertheless, many successful engineers will continue to find more satisfaction in a career devoted to the advancement of the state of the art than in a life devoted to risking money and men's jobs for the sake of more money and more jobs.

Should a young engineer specialize?

No. Most old-timers feel that the average beginning engineer should plan to bounce around in his chosen field for three or four years. During this time he can be picking up a lot of valuable experience so that he can evaluate his area of specialization the way he would evaluate a wife rather than a mistress—he'll be stuck with it for the rest of his life. It is universally understood that a young man is in a hurry, what with a marriage on his mind, or little mouths to feed, but some authorities recommend spending at least five or six years in the general field before settling on a specialty.

Why wait? Well, very few engineers fresh out of school are wise enough to discriminate among the specialties. And when a young man does decide to specialize he is faced with a very serious problem: how to avoid a field of specialization that will become obsolete overnight. While it is true that a first-class specialist can enjoy a good financial future in a field where demand is consistently high, how can he tell how long that demand will last? Just consider, for example, what must be in the minds of men specializing in reciprocating engines or vacuum tubes—as turbines or transistors and molecular electronics develop swiftly. Finally, the man who specializes too early runs the risk of getting into a stranglehold of specialization in a field he comes to hate. It takes time and shopping around to avoid this miserable fate.

What fields look most promising in the immediate future?

Atomic and nuclear power; data handling; communications; solid-state devices; test equipment; chemicals as materials and foods; new computer applications. All experts emphasize that these fields require a very strong base in fundamentals of the engineering sciences generally because they are developing so rapidly. Some of them, such as chemical-product areas, have been relatively ignored in the scurry for space supremacy, but represent a real and present area for engineering enterprise. Other areas, such as computer applications, are being exploited in some directions but ignored in others. When computers, for instance, are reduced in size and cost, they will revolutionize life as we know it today in such fields as law, medicine, and even homemaking. And there are new fields, such as plasma physics, virtually virgin. Within this generation it is likely that the atom will be controlled by means other than fusion and fission. We will be amplifying light as we have been amplifying microwaves. We will be exploiting cryogenics and converting low-frequency house current into powerful high-frequency radiation inexpensively and safely. "Buck Rogers?" That's what they said about Sputnik.

Should a young man go after an advanced degree?

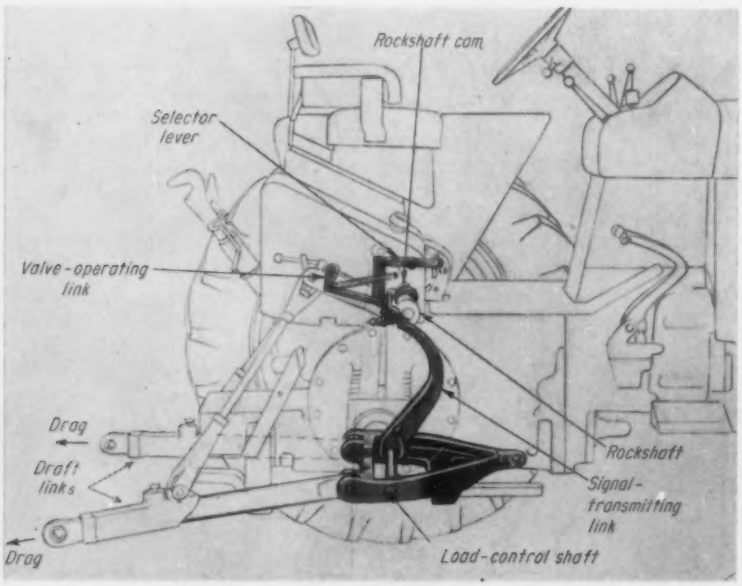
Yes. Everyone agrees that an advanced degree is desirable. In some companies it is absolutely essential to advancement. But even when it is not required for a better job, an advanced degree—or at least continuing study—keeps a young man up in his field. This does not mean that advanced degrees should be pursued at the expense of a happy home or poised nervous system. One night a week or a home study course would be enough for many people. (Study for a PhD deserves full time.) Much depends on personal motivation; one observer recalled Joe Louis's reply when asked why there were so few good heavyweights around: "They're not hungry anymore." Many good engineers do not go after advanced degrees because they are doing well without them. However, the experts feel that if things get rough, those with advanced degrees will continue to do well. In fact, the top executive of a small company confessed that he remains unhappy in his present position because he does not have the advanced degrees required to get a position where he would like to work. He is too old, he says, and too busy to get one now.

What about the over-all picture?

Great! The Class of '61 will emerge when the dust of our technological revolution is beginning to settle. They will come out with more knowledge of over-all technology than their predecessors had, and will face a promising future. They will have to put up with a lot of hard work and produce at an accelerated clip, and will have to ride out the switchover from mass production to unit production in fields such as aerospace. But it will be worth it. A surprisingly high percentage of top management in industry today is in the age group 35 to 45. It is perhaps more true than ever that for a good young man there will be plenty of room at the top. ■

Tractor Adjusts Itself to Farm Work

For example, it automatically lifts plow to prevent overload in rough going. Bolt-on power takeoffs adapt tractor to old or new implements, and 11-speed transmission gives it speeds from 1½ to 14 mph.



PS . . . Engine for 4010 tractor comes in models for diesel oil, gasoline or LP-gas. Central pump supplies hydraulic pressure that operates power steering and power spot-brakes as well as hitch control and coupler. Human-engineered seat is contoured and adjustable. Locating the gas tank in front of radiator gives better visibility, and keeps fuel cooler so that it retains the vapors needed for easy starting. Tractor is made by Deere and Co, Moline, Ill.

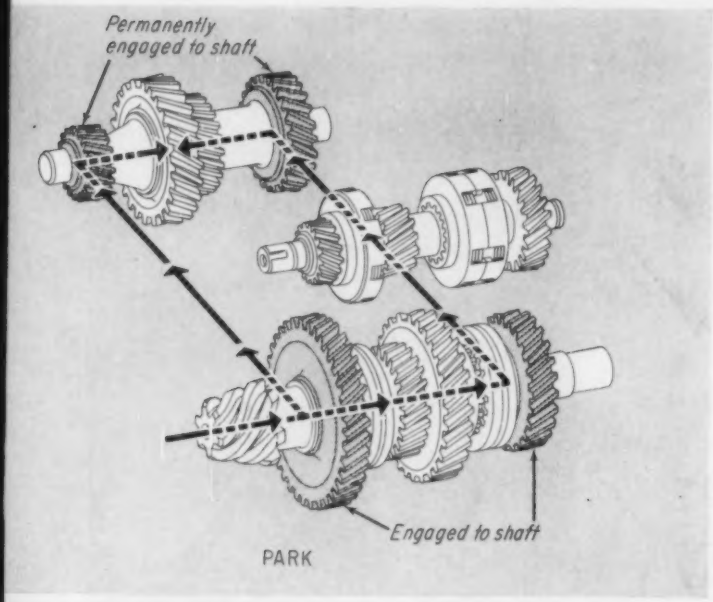
AUTOMATIC CONTROL, which can raise or lower plow or other implements attached to hitch, has three settings: 1) ON—control varies depth of plow according to conditions, to keep constant drag on tractor. 2) Modified ON—load-control action limited to extreme conditions; depth remains relatively constant. 3) OFF—plow stays at same depth, regardless of load.

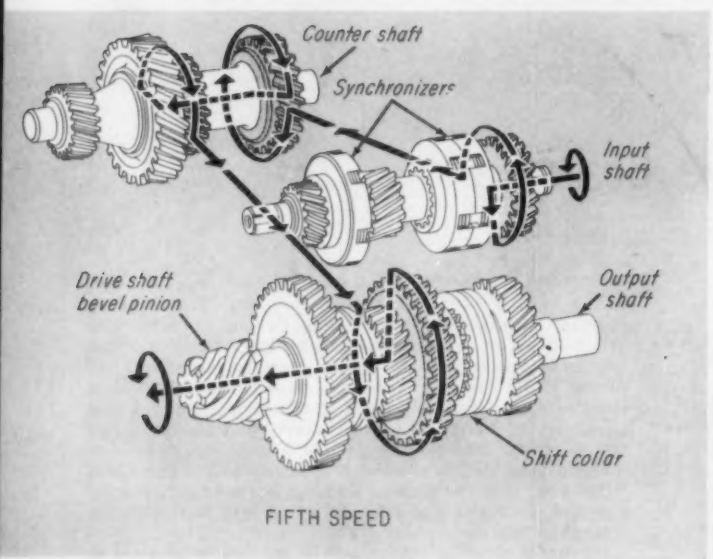
Control reacts to drag on draft links, which are attached to end of load-control shaft. Drag force bows the load-control shaft against linkage running to control valve. This valve commands hydraulic cylinder to raise or lower plow by rotating the rockshaft.

With load-control mechanism on, plow is raised or lowered as it passes through different kinds of soil. In denser soil, the plow raises to turn a shallower furrow; in lighter soil, the plow drops deeper. Drag signals go full-strength to control valve.

With modified load control, drag signals are modified by feedback from the rockshaft cam. Only extreme drag forces make the plow raise appreciably to relieve load on engine. This setting is for jobs where only the toughest spots could cause overload.

With load control off, after operator manually sets initial depth for plow, it doesn't change, because signals to the valve are cut out. A separate lever (not shown), which controls the rockshart through 75° rotation, allows further manual depth changes.





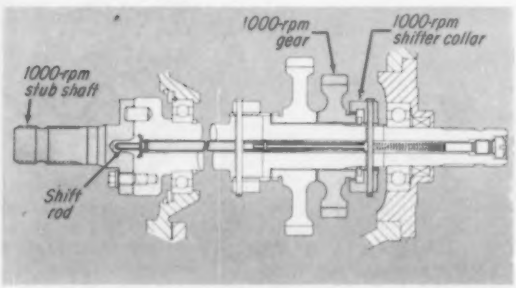
CONSTANT-MESH TRANSMISSION has eight forward speeds, three reverse speeds, park, and neutral (for towing). These ratios give tractor speeds of 1.52 to 14.26 mph at 1900 engine rpm.

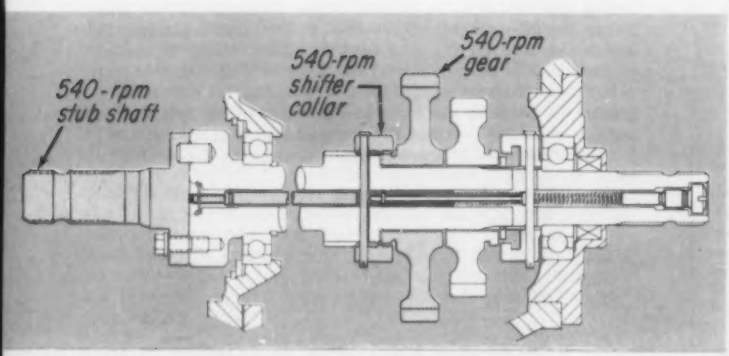
All gears on countershaft are locked to the shaft. None of the gears on the input and output shafts is permanently engaged. Engaging one gear to the input shaft and one to the output shaft changes speeds.

Because gears on the input shaft have synchronizers they can be engaged while the tractor is moving. To engage gears on the output shaft, the tractor must be stopped. However, each gear on output shaft serves two final gear ratios; and operator can avoid stopping by shifting between these two speeds while on the move. He does it by selecting a different synchronized gear.

In neutral, all gears on the input and output shafts are disengaged.

In park, two gears that engage simultaneously on each shaft lock the transmission.

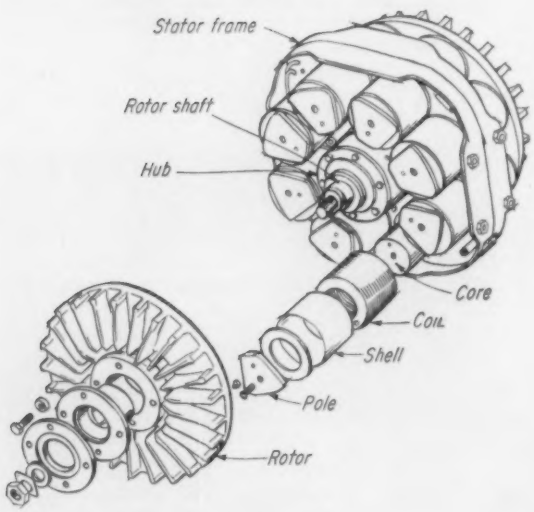




POWER TAKEOFF for attached implements is supplied by two bolt-on stub shafts—one for 540-rpm equipment; the other for newer 1000-rpm equipment. Each of the splined output shafts automatically shifts gears for right speed. At end of internal pushrod is a spring which keeps 1000-rpm gear engaged and 540-rpm gear disengaged. Stub shaft for 1000 rpm has recess that prevents it from touching pushrod and disturbing speed setting. Stub shaft for 540 rpm has no recess; it depresses pushrod, engaging the 540-rpm gear and disengaging 1000-rpm gear.

Electromagnetic retarder absorbs rolling energy of heavy vehicles. This reduces load on brakes and provides effective slowdown in an emergency.

Eddy Currents Do the Braking

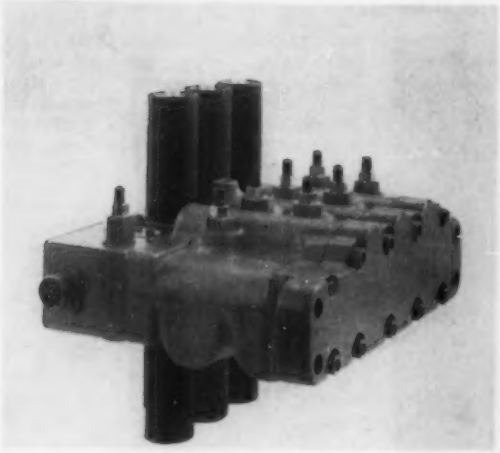


PS . . . Retarder alone will hold the speed of a 14-ton truck to 22 mph on a 9% grade. Reduction in brake-lining wear is significant, since retarder takes over all braking that does not require a full stop. In case of complete brake failure, retarder enables driver to maintain control, even on steep grades. These retarders, for trucks up to max gross weight of 35 tons, are produced by Lear Inc, Electro-mechanical Div, Grand Rapids, Mich, under license from Compagnie Telma, Paris, France (PE—Nov 14, p 20).

ELECTRIC RETARDER is a coupling—two finned rotors, and a stator with electromagnetic coils. For braking, operator of the vehicle energizes the stator coils with current from the storage battery. Eddy currents are then generated by the relative motion between stator and the rotors. These currents produce a second magnetic field in the iron rotor; this field tends to retard rotation. Locking the stator half of coupling to the vehicle frame transfers the retarding force to the vehicle wheels. Magnitude of the retarding torque is directly proportional to the speed of the rotor and the current supplied to the stator. Energy absorbed by the retarder is converted into heat and dissipated by the cooling fins on the rotors.

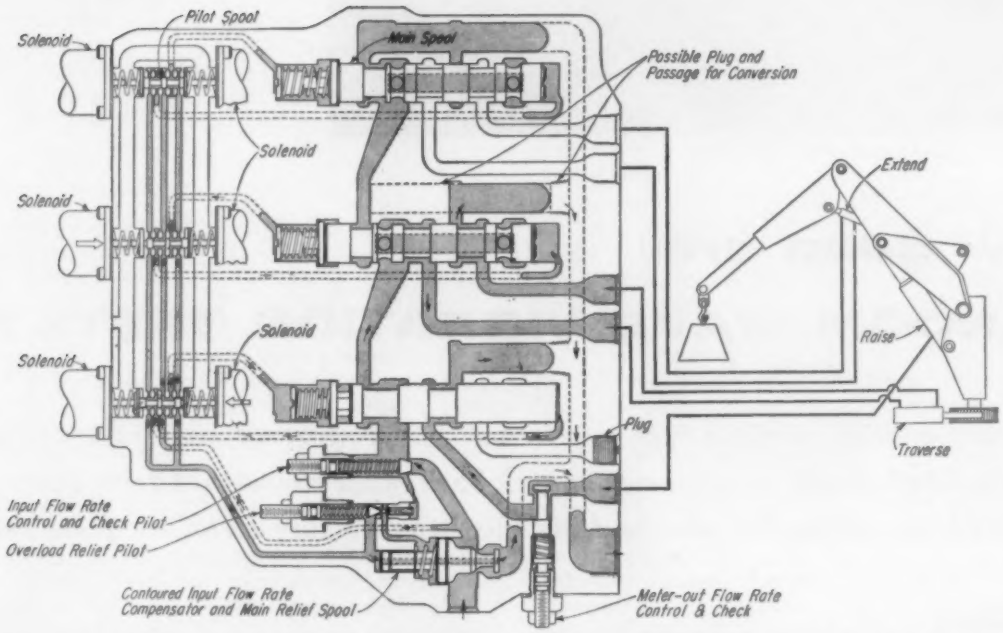
Current-flow to the stator coils is controlled by a 4-position switch mounted on the vehicle's steering column. The switch successively energizes four circuits, giving the driver a wide range of retardation. Maximum retarding force can be generated in two to three seconds.

Stator consists of a double circle of electromagnets bolted back-to-back on a steel frame. Central hub of this frame provides support for the antifriction bearings in which the rotor shaft runs. Frame of the stator is bolted to the chassis of the bus or truck on which the retarder is mounted. Rotors, mounted on each end of the rotor shaft, become a part of the vehicle drive-line. The retarder is usually mounted between the transmission and differential; it retains its effectiveness even if engine or transmission fail.



Hydraulic Valves Supply Own Manifold

The three solenoid-operated valves are in the same housing—drilled for passages that distribute oil.



COMBINATION VALVE controls a truck-mounted boom in application shown in operation diagram. The only external connections needed are a supply line from the pump, a return line to the tank and a line to each end of the three cylinders. Drilled internal passages replace manifolds and interconnecting lines between the valves, which could loosen or break. Return oil empties into a single gallery and leaves the housing through a single line. Supply oil passes from valve to valve internally.

Single-package construction makes it easy to mount valve close to the cylinders, thereby reducing length of lines to the cylinders.

Additional drilling and plugs can adapt the combination valve for different jobs. In this version, a plug closes one port not needed for the single-acting cylinder that raises the boom. If it were necessary for the top and middle spools to operate at the same time, another passage could be drilled and a plug added to supply oil to the top spool, no matter what the position of the middle spool. Without such alteration, top spool cannot operate simultaneously with middle spool.

Cable from operator's hand-held set of contact buttons plugs into pin connector on side of valve. Commands from buttons actuate solenoids to shift pilot spools, which divert oil to either end of the main-valve spools. Main-valve spools direct oil to and from power cylinders.

In the same housing, a contoured spool, controlled by two pilot valves, regulates input flow and also serves as relief valve. Other flow-control valves, in the passage to each cylinder port, control the return flow. Pilots and return-flow controls all have individual adjustments.

PS . . . This three-spool valve and a similar two-spool model can be bolted together to form multiple-spool combinations. Solenoids can be operated manually as well as electrically. Adjustable range of relief-valve function is from 100 to 3000 psi. Combination valve is made by Double A Products Co, Manchester, Mich.

RANDOM-WAVE GENERATOR is a much more complex piece of equipment than that needed for simple sine tests. Shaded areas show those pieces of apparatus that could be discarded if the facility were used only for sine tests. This machine is a Ling-Temco, 5000-lb-force random-vibration tester installed in Kearfott's environmental testing laboratory. The shaker table and power supply are in the room beyond the window over the control console. Kearfott has 15 vibration-testing machines in this lab; sizes range from 600-lb-force to 5000-lb-force.

how good are RANDOM-WAVE VIBRATION TESTS?

Presumably they're more "realistic" than the traditional sine-wave tests—but are they? From his experience with both types the author feels that specifications calling for random tests should be sharply curtailed. Here's why.

C G STRADLING
Kearfott Div, General Precision Inc

A strong difference of opinion is splitting test engineers nowadays. It concerns the relative merits of pure sine waves vs random waves as the best way to check out equipment that will spend part of its working life in vibrating environments. An increasing number of government contracts are now specifying random-vibration tests in acceptance procedures. It is my contention that most of these test dollars are wasted, that simple sine tests give nearly the same information and do it with much less trouble and much smaller investment in test equipment.

First let us see exactly what procedure is followed in each test:

Sine-wave vibration. The usual procedure is to mount the part on a shaker table and vibrate it at several specified frequencies or over a continuously varying band of frequencies within a specified range (limits are from about 10 cps up to as high as 2000 cps nowadays). Because sine waves are easy to generate and because shaker tables generally respond more readily to sine-wave signals, this method has the advantage of simplicity and results that are relatively easy to analyze.

Random-frequency vibration. You need give the shaker only a single short burst of random-frequency energy to do the testing job. This, at least, is the claim of those who endorse the method. And even more important, they insist, the random waves give a better representation of the actual environment.

Shaker limitations

Neither claim for random vibration is completely true because neither reflects a very realistic view of the capa-

bility of vibration-testing equipment or of what happens in actual vibrating environments. In the first place, there is a difference between the vibration composed of a random selection of discrete frequencies and environmental vibration in which a broad band of frequencies occurs simultaneously. This is why random vibration (or, as it is erroneously called, "white noise" vibration) falls short of simulating an actual environment. Even if the random signal could be an accurate representation of the actual environment, there are no shakers available that can reproduce a truly "white" band signal.

Second objection is that the environment itself has an irregular frequency spectrum. The test engineer goes to great pains to avoid resonance in the shaker table and fixtures so that the unit will give flat response over the full range of frequencies. But in the actual environment there are always peaks and notches because of local resonance. One might ask, "Why can't we just record our actual-vibration environment and play it back through the random-vibration equipment? If the response of the equipment is truly flat, this should give a good approximation." Again, the answer is that it would ask too much of the shaker. The mechanical equipment just can't respond linearly to such an input.

Is environment random?

But suppose we could build the equipment; would it be worth the trouble? First, it must be recognized that when components are installed in the airframe, missile, or machine-tool, vibration will come from both acoustic and structural sources. For this reason, both acoustic and mechanical couplings are used in the test laboratory. But in an actual environment, mechanically coupled vibration is filtered by the structure and it is chiefly sinusoidal. Even acoustic energy will be primarily composed of a few discrete frequencies because of resonances at the source. Therefore, a sine-wave test is a closer approximation of the actual vibration than it might appear.

Further, acoustic energy is a function of air density and decreases with increasing altitude of the missile or aircraft. At the present time, there are few applications, other than missiles, where acoustic energy is really significant. In a few years, perhaps, when aircraft speeds move up to Mach 2 and beyond, acoustic energy will become a major consideration.

Besides the questions of whether it is possible to reproduce random vibration and whether such a vibration, if reproduced, is a good copy of the real thing, there is also the question of whether such tests, even though inadequate, have any real value. Never in my experience has any structure that failed with random, mechanically coupled vibration resisted failure under sine-wave vibration. The converse cannot be said. And in detailed vibration analysis, design engineers almost always use sine energy to hunt down an offending structure or component. While there are certain "classic" examples of vacuum tubes or relays that had their weaknesses "discovered" by random vibration, it is my opinion that careful sine-testing would have uncovered these weaknesses just as well—only cheaper and faster. And results of the sine tests would have been much easier to analyze.

More expensive

I have implied that random testing is much more demanding and time-consuming than sine testing. Let me expand on this point. Random testing has been advertised as a time-saver. Specifications commonly call for a three-minute burst of random vibration as compared to 15 minutes of sine energy. But this is not the end of the story. The random-test set-up time is from ½ to eight hours per axis, compared to five minutes to one hour for sine vibration—and most vibration tests include all three major axes. Further, if the test is anything more than a plain destructive test, or if analyzing or searching is involved, it can be done far more quickly on the sine equipment.

Besides the labor cost, consider the expense of the excitation and monitoring equipment. A complete 5000-lb-force sine-shaker system costs around $40,000. A "poor man's" random system might be purchased for $60,000 but it would be practically useless for anything more than simple destructive testing. And a complete 5000-lb-force random system with recording, analyzing, and monitoring equipment would run about $150,000. These figures are total costs; the equipment alone is expensive but a significant portion of the total cost is expended in installation and accessories.

Maintenance costs are higher too. Random-vibration machinery is more complex and this means a decrease in reliability. It has been shown that only a small increase in the number and complexity of a system's components causes a rapid decrease in system reliability. This has been called the "avalanche effect." It has been my experience that an electronic sine system (many are mechanical) has a reliability of 0.66 after initial debugging. That is, it requires one hour of service for every two hours of operation. A comparable random system shows a reliability of 0.5 (one hour of service for every one hour of useful work). This, of course, further increases the cost of random testing. And there is nothing more upsetting to the environmental engineer than his need to tear down a carefully prepared test setup because the equipment is inoperative and must be serviced. It is difficult to estimate the actual cost of downtime in terms of lost production, but this is certain to be a significantly large figure.

For these reasons, it is my opinion that the use of, and requirement for, random-vibration testing should be severely curtailed. And in most of those few cases where it must be specified, it should be restricted to acoustic coupling. Since waves give an adequate representative of most environments and they are the most suitable waveform for our present test equipment.

EDITOR'S NOTE: For more about vibration testing, both mechanical and acoustic, see:

For Rough Handling . . . These Shock Tests, May 11 '59, p 74. Two simple methods for test-dropping a product and examples of each.

Structural Vibration—An Oscilloscope Tells the Story in Pictures, Feb 2 '59, p 52. Scope patterns show resonances, locate trouble spots.

Mockups for Vibration and Shock Testing, July '53, p 186. Inexpensive models test vibration and shock resistance of proposed structures.

REVERSAL OF ELECTRIC MOTORS

Some motors are easy to reverse; others aren't. Here's how the most popular types are adapted for two-way operation, plus an indication of the complexity involved.

A K DAS GUPTA, design consultant, Chicago

When you must reverse a motor quickly—in anywhere from a fraction of a minute down to a fraction of a second—complexity of the reversing circuitry becomes at least as important as motor type, and can make the cheapest motor one of the most expensive in the long run. Slow reversal of motors—where the motor is stopped gradually, then slowly accelerated in the opposite direction—is generally associated with variable-speed motors. This method will be covered in a coming article.

Some types of constant-speed motors are easier to reverse than others. For example, dc series and shunt motors, and ac polyphase, capacitor-run, and capacitor-start motors, need only minor changes for reversal. On the other hand, repulsion, synchronous and shaded-pole motors are much less practical to reverse. Here is a rundown of how to reverse each of the standard motor types.

DC MOTORS

Any dc motor can be reversed by reversing either the armature or field current. In some cases it may be simpler (therefore less expensive) to reverse the armature current; in other cases, depending on type of winding or size of the motor, it may be better to reverse the field.

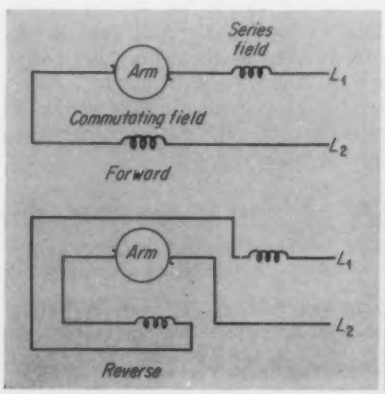
Dc series motors can be reversed by means of a controller, either manually-operated drum type or automatic. Reversing the armature current is simpler, but if the motor has interpoles, the interpole current must also be reversed as shown in Fig. 1.

Small dc shunt motors can be reversed by a relay which reverses armature current (Fig 2). Relays for this purpose have recently been introduced by several manufacturers. Another way uses a controlled rectifier with a magnetic amplifier. This rectifier has characteristics somewhat similar to a thyratron. Where load inertia is high, the controlled rectifier must be protected against overheating because the duration of armature current while reversing may be long enough to cause damage.

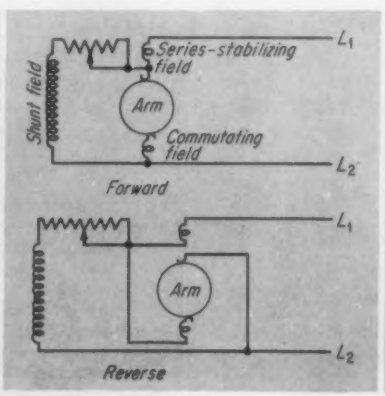
Shunt motors carry a relatively high armature current; at the instant of reversal, the back electromotive force will add still more to this current. Reversing the field current might appear to be more practical, but this introduces two disadvantages. The high inductance of the field circuit produces high-voltage switching surges, and the armature may overspeed from loss of field during switching. Reversing the armature current is best for small motors, but armature diameter should be small to keep armature inertia at a minimum.

For larger motors, load current and armature inertia both increase. At some specific size, the armature-switching device becomes more expensive than a field-switching device, and it is more economical to reverse field.

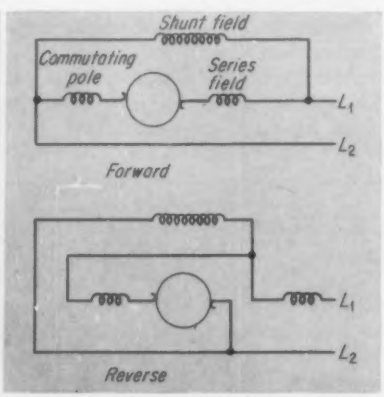
Large dc shunt motors are reversed by contactors equipped with blowout coils, which effectively break the inductive arc by lengthening it. Discharge resistors are used with reversing contactors to avoid excessive voltage rise when contacts are opened.



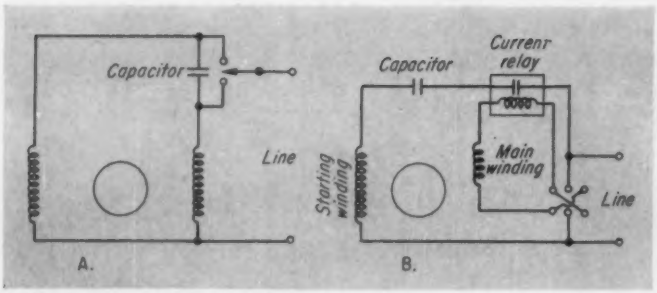
1—Series



2—Shunt



3—Compound



4—A. Capacitor-run; B. Capacitor-start

Compound motors can be reversed by a controller. Reversing the armature and commutating poles is generally simpler (Fig 3).

AC MOTORS

Single-phase motors

Single-phase current cannot, by itself, start an armature rotating, but once you get the motor going, it will continue to rotate at or near synchronous speed. Single-phase motors use a variety of means to gain starting torque, and each requires special switching arrangements for reversal.

Split-phase motors can be reversed by a relay that will reverse either the main or auxiliary winding. Split-phase motors that contain a centrifugal switch to disconnect the starting winding as the motor reaches rated speed cannot be reversed until the motor slows down so the starting switch can close. For applications requiring repeated reversal, a motor without this centrifugal switch is simpler to reverse.

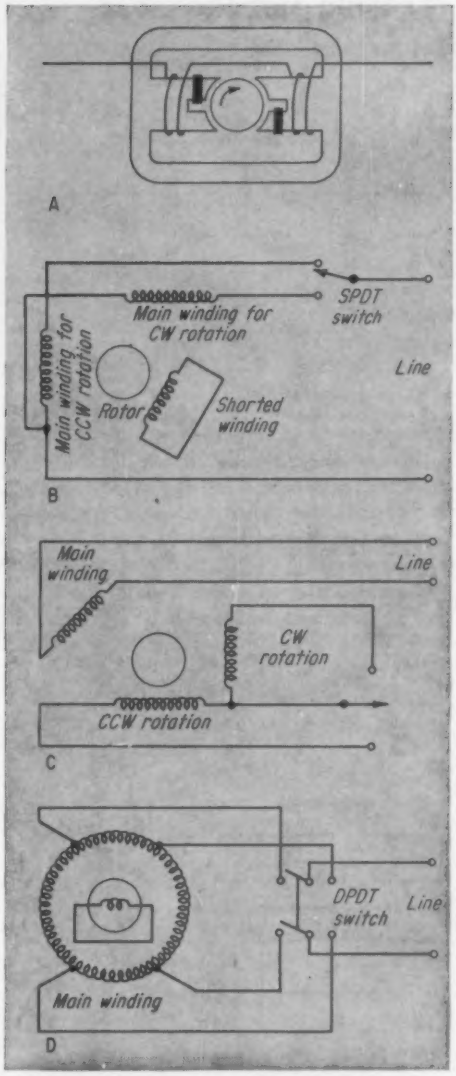
For cyclic-reversal applications, such as laundry machines, a magnetic reversal switch can be used in combination with a synchronous timer.

Another method, used experimentally, has a switch that short-circuits the stator during switching, with a small series resistor to limit the short-circuit current. The starting winding is disconnected and frequency reduced during switching. Reversal time depends on rotor and load inertia, but is quite fast. For example, a motor at full load on 25-cps power reverses in less than ½ sec.

Capacitor-run motors can be reversed by SPDT (single-pole double-throw switch) as shown in Fig 4A. Because the two main windings are identical, the switch position determines which winding serves as the auxiliary winding through the capacitor.

Capacitor-start motors can be reversed by a two-pole double-throw controller if a current relay is used with its coil in series with the main winding (Fig 4B). Relay contacts are connected in series with the starting winding and capacitor. When power is applied, the high starting current pulls in the relay and energizes the starting winding. At full-load speed, the current drawn by the main winding drops, and the relay contacts open, disconnecting the starting winding.

When the controller is reversed, the relay contacts close to activate the starting winding with a current in the opposite direction. This current produces a retarding torque, which stops the motor and starts it in reverse. When the motor reaches 70 to 75% of full-load speed, the current drawn by the main winding drops low enough to reopen the relay. Power supply must be good enough to assure constant voltage at the motor, to avoid drop-out of the relay caused by line-voltage dips.

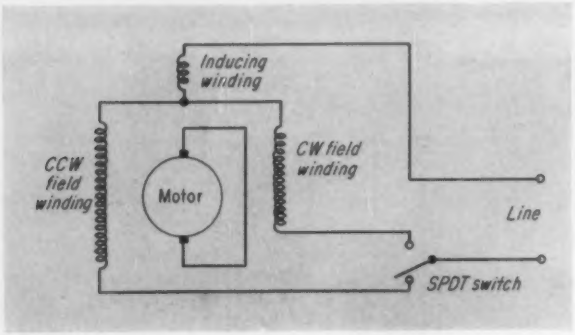


5—Shaded-pole. A—Standard; B, C, D—three special reversing designs.

Shaded-pole motors (Fig 5) have a wound stator and a squirrel-cage rotor. Starting is accomplished by "shading" a portion of the magnetic circuit with shorted windings to produce rotation of the field. To reverse the motor, the rotation of the field may be reversed by connecting alternate sets of shading coils, or separate main windings may be provided for each direction. These complex methods of reversal ordinarily add too much to the cost of the drive.

Repulsion motors have single-phase ac stator windings, and rotor windings are connected to commutators as in dc motors. Brushes on the commutator are short-circuited and their position adjusted so that the magnetic axis of the rotor winding is inclined to that of the stator winding.

continued, next page



6—Repulsion-start

To reverse direction, the brushes are shifted, or a second set of brushes is provided and shorted as the first pair is opened. If the motor has a compensating winding, it must also be reversed along with the brushes. This system develops plugging torque, which causes rapid reversing.

Repulsion-start induction motors for reversing service require two field windings—one for each direction. A SPDT switch will provide quick reversal as shown in Fig 6.

Synchronous motors are reversed in various ways, depending on the method used to start them. Starting torque is provided by one of the single-phase starting systems previously explained.

Hysteresis motors do have starting torque and can be reversed by changing direction of the rotating magnetic field.

Universal motors can be reversed by reversing the field winding or commutator connection; field-winding reversal generally is preferred. A single field coil will require a DPDT switch; or two field windings can be provided, one for each direction, in which case a SPDT switch will do (Fig 7).

Three-phase motors

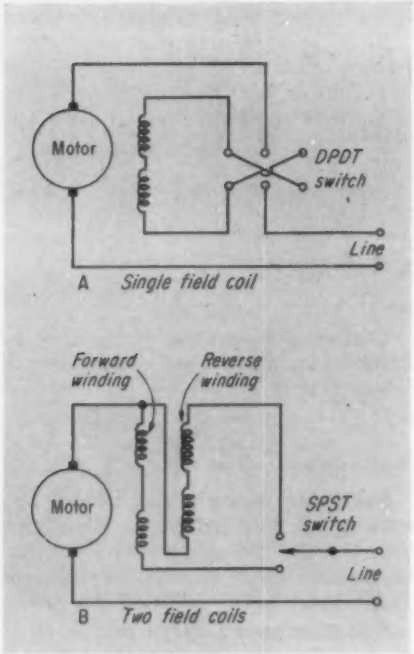
These motors all reverse by reversing phase rotation, which changes direction of rotating field. With plugging relays, resistors are used to limit inrush current. Induction motors with wound rotors require current-limiting resistors in the rotor circuits.

For slightly slower reversal, saturable reactors can be used. This method uses two reactors as two-pole reversing contactors. Effective speed control is possible, and reversal is accomplished without opening supply lines to motor.

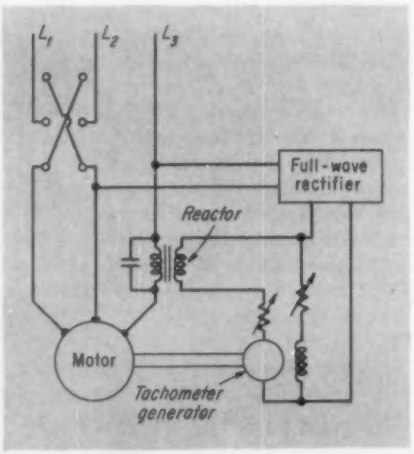
Another method uses a capacitor in parallel with one saturable reactor. The capacitor reverses the sign of the reactor, thereby reversing the motor.

Dynamic braking can be combined with reversing on a high-torque motor with a tachometer generator supplying a signal, which is proportional to speed, to a control reactor (Fig 8).

Contactors used to reverse low-voltage motors must interlock mechanically and electrically. For high-voltage motors, separate control sources or control transformers must be used. Proper potential interlocking must be used when an air-brake reverse-switch is used, to protect against short circuits in the line.



7—Universal



8—Three-phase with dynamic braking

EDITOR'S NOTE: For more information on stopping and reversing electric motors, see:

What They're offering in Electrical Controls, Sep 26 '60, p 37—Machine-tool exposition report covers many motor controls, including, on p 40, a dc-motor reverser that uses silicon controlled rectifiers triggered by special magnetic device to change current flow from full forward to full reverse.

Four Ways to Stop a Motor, July 6 '59, p 60—Author compares four methods—mechanical, plugging, dc dynamic braking, and capacitor braking—for stopping an induction motor. Table lists advantages, disadvantages and precautions.

COMING SOON—an article on controlled reversal of variable-speed direct-current motors.

when was that patent issued?

The answer can be found with this table. For a close approximation of the date, all you need is the patent number.

GEORGE SZEKELY, *Norland Associates Inc*

The law provides that a patent number be placed on every patented article. That number doesn't tell us much unless we are willing to do some research in a patent library or write the Patent Office. But often, all we want to know is the date of issuance. You can find it (often to within a month or two) from the table below.

There are many occasions when it is convenient to know a patent's issue date:

- to determine expiration date (usually 17 years after issuance)
- to evaluate the pace of development
- to determine state of the art when the patent was issued
- to help find a patent when searching files that are indexed by date (often the case in public libraries)

From the numbers listed below, you can bracket the date. And by interpolating between numbers you can make a reasonably accurate estimate of the actual date. Patents issued between the first patent statute in 1790 and the opening of the Patent Office in 1836 were not serially numbered and therefore are not listed. Reissues—patents that have been corrected after discovering a substantial error—are numbered separately. But the term of a reissued patent is still reckoned from the original issue date. For historical reference, the table cites 20 of the most significant US inventions and their inventors.

NUMBER	DATE
1	**7/13/1836**
1,647	*6/20/1840—Morse* (Telegraph)
3,633	*6/15/1844—Goodyear* (Vulcanized Rubber)
4,750	*9/10/1846—Howe* (Sewing Machine)
16,444	*1/20/1857—Kelly* (Steel Converter)
20,000	4/20/1858
36,836	*11/4/1862—Gatling* (Machine Gun)
40,000	9/15/1863
60,000	11/27/1866
79,625	*6/23/1868—Sholes* (Typewriter)
80,000	7/14/1868
88,929	*4/13/1869—Westinghouse* (Air Brake)
100,000	2/22/1870
140,000	6/17/1873
174,465	*3/7/1876—Bell* (Telephone)
180,000	7/18/1876
200,000	2/5/1878
223,898	*1/27/1880—Edison* (Incandescent Lamp)
240,000	4/12/1881
280,000	6/26/1883
300,000	6/10/1884
347,140	*8/10/1886—Thomson* (Electric Welding)
380,000	3/27/1888
388,950	*9/4/1888—Eastman* (Roll-film Camera)
400,000	3/19/1889
400,665	*4/2/1889—Hall* (Aluminum Reduction)
400,000	11/4/1890
480,000	8/2/1892
500,000	**6/20/1893**
504,038	*8/29/1893—Judson* (Slide Fastener)
520,000	5/15/1894
560,000	5/12/1896
586,193	*7/13/1897—Marconi* (Wireless Telegraphy)
600,000	3/1/1898
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750,000	1/19/1904
775,134	*11/15/1904—Gillette* (Safety Razor)
800,000	9/19/1905
821,393	*5/22/1906—Wright* (Airplane)
850,000	4/9/1907
900,000	9/29/1908
942,700	*12/7/1909—Baeckeland* (Bakelite)
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1,689,847	*10/30/1928—Zworykin* (Television)
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REISSUES	
1	1/9/1838
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4,000	5/31/1870
5,000	7/23/1872
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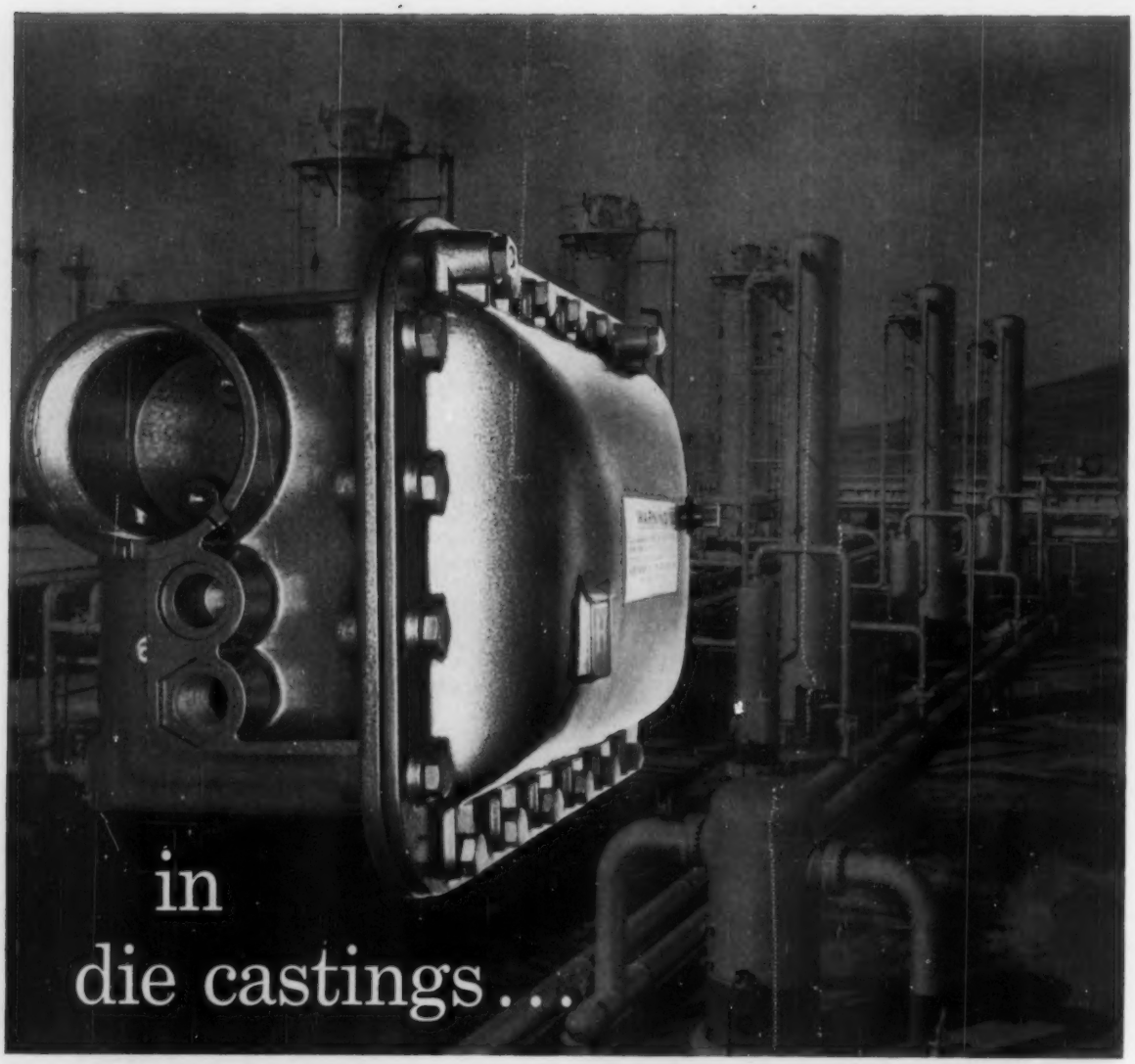
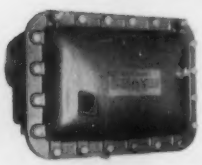


Alcoa puts the metal where you want it



High-volume output and low cost were the twin objectives. That's why Minneapolis-Honeywell decided its new Process Pressure Transmitter must be housed in an aluminum die casting.

The housing had to be explosion-proof—for it would operate in Class 1, Group D, Division 1 locations. This called for thick walls—especially so for die casting. Mating faces had to meet flush—metal to metal—without gaskets.

These were stiff conditions—demanding a new application of the die-casting process.

Honeywell turned to Alcoa—the company with the most experience in the aluminum industry.

Working closely with Honeywell, Alcoa development engineers designed a die casting that's little short of stupendous. It's made of Alcoa's new high-strength, high-elongation casting alloy 364, which has the properties of alloy 218. Yet, the new alloy is more economical because it is easier to cast.

Hydrostatic tests proved that sand-cast prototypes withstand 500 psi, more than enough to assure that castings would withstand explosive pressures up to 125 psi. Mating faces—*as cast*—meet with an integrity that eliminates any need for a gasket.

In castings as well as forgings, impacts, extrusions and screw machine parts, Alcoa puts the metal where you want it. Learn more about Alcoa's ingenious solutions to difficult design problems—write to Aluminum Company of America, 908-M Alcoa Building, Pittsburgh 19, Pa.

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ALCOA ALUMINUM

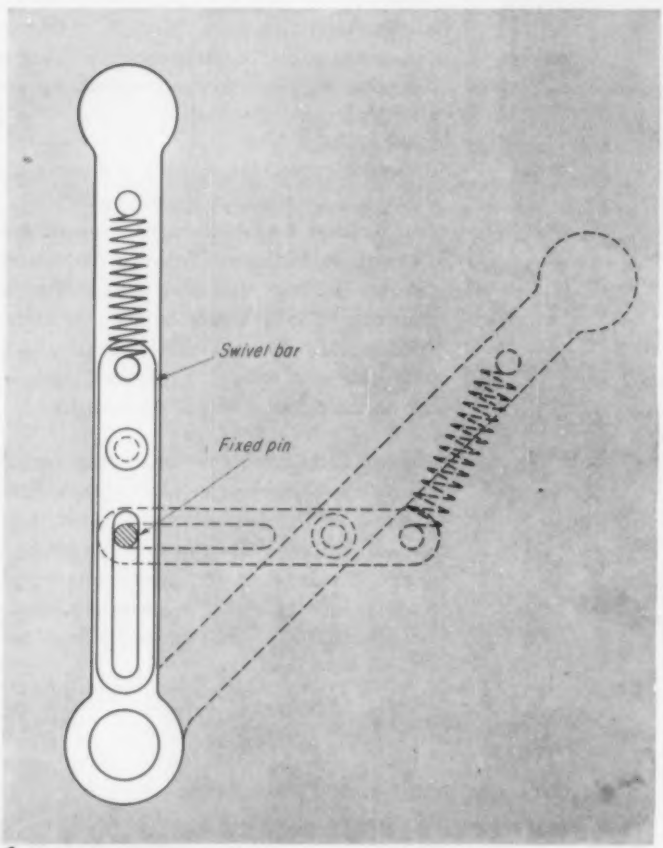
ALUMINUM COMPANY OF AMERICA

6 more designs in which

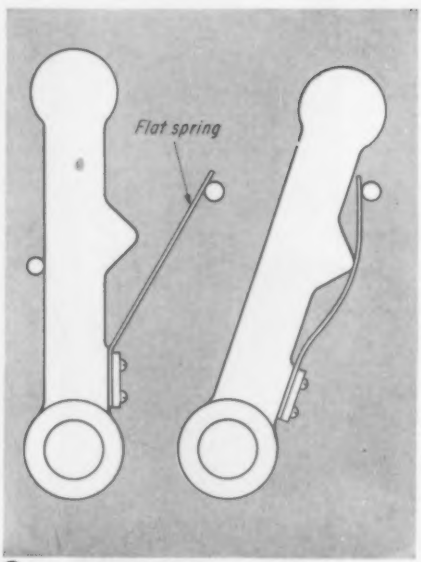
ONE SPRING RETURNS THE HAND LEVER

A flat, torsion or helical spring does the job alone. Other such designs appeared in the Nov 21 issue.

L KASPER, *consultant*
Philadelphia

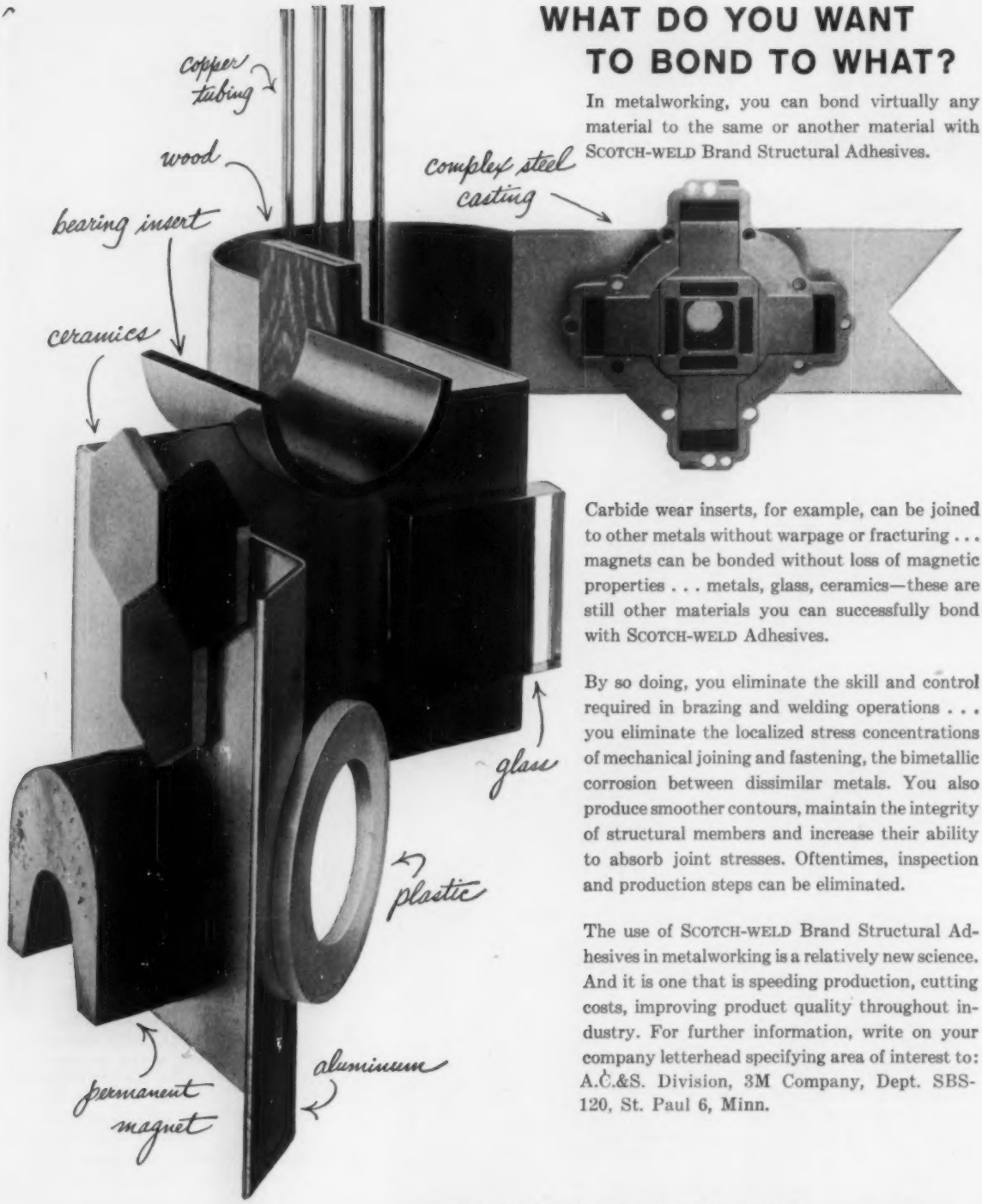


1
SWIVEL BAR, which slides on fixed pin, returns hand lever. Slot in swivel bar is limit stop for movement either way.



2
HIGHER SPRING RATE, when the projection hits the flat spring, warns operator he's approaching end of travel and assures quick disengagement.

continued on page 91



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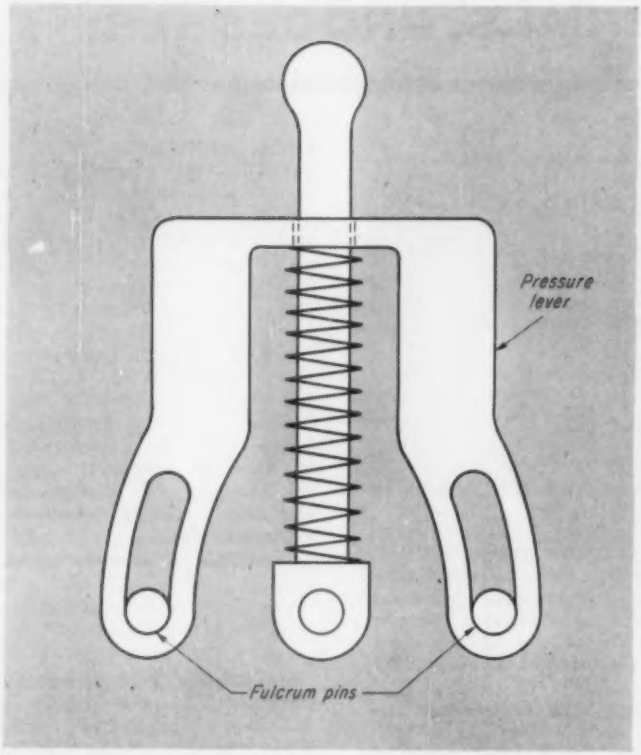
ADHESIVES, COATINGS AND SEALERS DIVISION

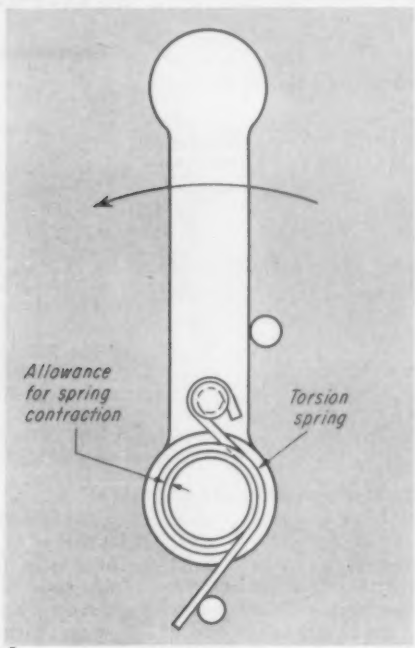
MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

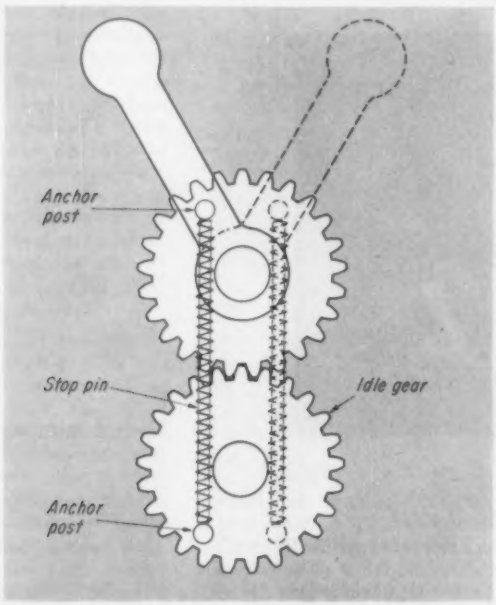
3M COMPANY



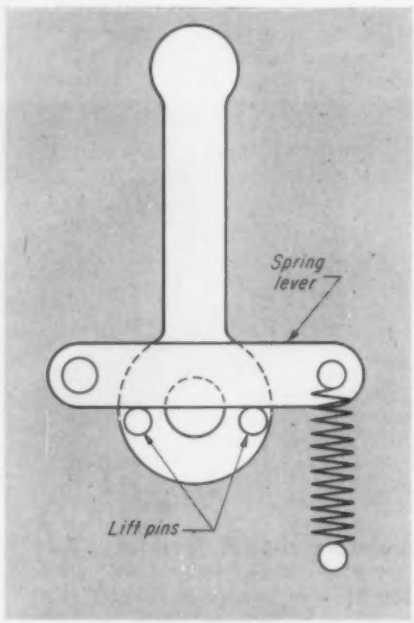
3
DOUBLE PRESSURE-LEVER returns handle to center from either direction by compressing spring. Lever pivots on one pin and comes to stop against the other pin.



4
TORSION SPRING must have coil diameter larger than shaft diameter to allow for spring contraction during windup.

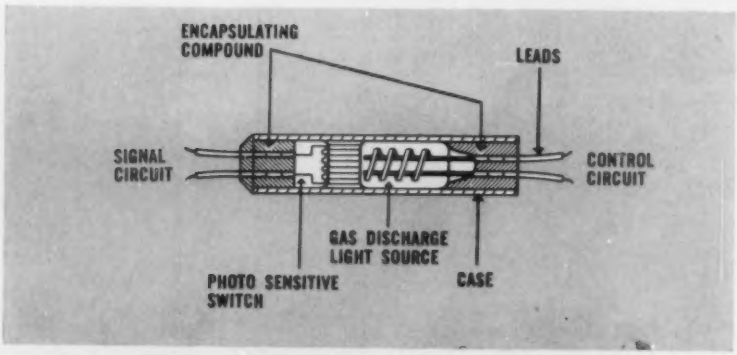


5
LEVER flops to stop because of spring pull. Stop-pins inside springs limit movement.



6
SELF-CENTERING HAND LEVER returns to vertical as soon as it's released. Any movement lifts spring lever and creates a righting force.

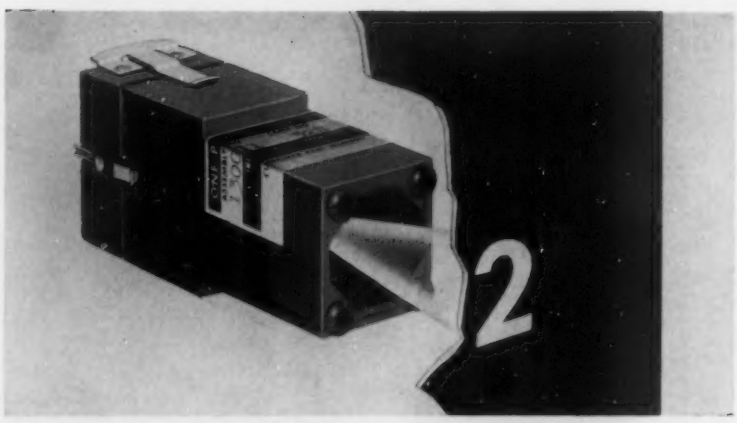
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Electro-optical potentiometer . . .

can be used to amplify signal (voltage to resistance) within narrow voltage range (0 to 1.5 v in one model; 0 to 24 v in another) or to control resistance. Resistance across polycrystalline photoconductor terminals varies with voltage applied to light-source terminals. Photoconductor has 75-mw power capability and a resistance change of approximately 10^8 over control-voltage range. Priced at $9 each in quantities of one to 24 and $7 each in quantities of 25 or more. **Raytheon Co, Industrial Components Div, 55 Chapel St, Newton 58, Mass.**

Circle 300 on Reader Service Card



Miniature digital readout . . .

for computers and control and test equipment, rear-projects ⅜-in. digits onto lucite viewing screen, which can be swung out of position when required. Digits, visible from any viewing angle, are uncluttered by mounting holes or other detail on front of readout. Light source comes from subminiature lamps, either No. 327, 328 or 330. Voltage is from 6 to 28 v. Subpanel-mounted unit measures 3⅛ x 1 x 1⅛ in. and weighs 3¼ oz. Available in assemblies or as single units at $35 each. Delivery, 30 days. **Industrial Electronic Engineers Inc, 5528 Vineland Ave, North Hollywood, Calif.**

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Linear transducer . . .

measures a few thousandths of an in. deviation from mechanical null. Teams with conventional panel meter for signal indications or with meter-relay for testing parts or automating machine tools. Converts linear position to signal that reads out on meter, needing no amplification. Sensitivity, as indicated on meter, is ±.005 in. full scale. Max readout speed is approximately 1 per sec. Full-scale meter accuracy is ±.0002 in. and reproducibility ±.0001 in., when constant-voltage transformer is used. Price: $95 for transducer with panel meter; $215 for transducer with continuous-reading meter-relay. **Assembly Products Inc, Chesterland, Ohio.**

Circle 302 on Reader Service Card

Steel tubing is centrifugally . . .

cast in ceramic-lined metal flasks. Eliminates need for special dies or patterns to produce tubes that meet high-pressure, high-temperature requirements or specific designs in rolls and hydraulic cylinders. By varying thickness of ceramic lining, given-size flasks can make tubes with outside diameters ranging from 2½ to 50 in. and wall thicknesses from ¼ to 8 in. Standard length is 20 ft. Tubes cast by this process are reported to be hot tear and crack-free. Metals used include carbon steel, low-alloy steel, heat-resistant and corrosion-resistant stainless steels and both plain and alloy cast iron. Actual cost figures not given, but materials used are reported to be less expensive than those in other processes. **American Cast Iron Pipe Co, Special Products Div, P O Box 2603, Birmingham 2, Ala.**

Circle 303 on Reader Service Card

Nickel plating . . .

produces satin-type finish directly from plating bath. Two-tone effect can be obtained by buffing raised surfaces to high luster. In scratch-brush finishes, all-nickel plate applied remains on item. Tests indicate high corrosion-resistance. Now in pilot plant production, finish is expected to be generally available by fall, 1961. **Udylite Corp, Detroit 11.**

Circle 304 on Reader Service Card

Position indicator . . .

continuously reads up to 10 ft of mechanical travel or fluid level. Traveler, or float, rides along probe, which is remotely or directly connected to direct-reading receiver. Probe-enclosed follower, magnetically coupled with moving traveler, shunts out part of resistive circuit across which receiver meter is connected. Varied-form travelers can be secured to any linear-motion device. **Gems Co Inc, Sheppard Lane, Farmington, Conn.**

Circle 305 on Reader Service Card

Stainless steel scroll . . .

based on a Neg'ator constant force spring, stores and displays such printed information as scale readings, position indications or instructions. Self-coiling design eliminates secondary drive equipment. Drums are kept taut by built-in spring tension. **Hunter Spring Co, Div of American Machine & Metals Inc, 1 Spring Ave, Lansdale, Penna.**

Circle 306 on Reader Service Card

Titanium diboride . . .

in fine, high-purity powder form, can be fabricated into a variety of shapes and sizes. Flexural strength of the refractory is stated at 35,000 psi over a temperature range of 77 to 3632 F. Weight is approximately half that of stainless steel and only 12% greater than alumina. Although hardness (in the range of boron carbide) makes fabricated titanium diboride unmachinable except with diamond tools, intricate shapes can be machined with conventional tools during processing stages. Reported to resist oxidation at 1832 F and show low oxidation rate at 2552 F. Electrical resistivity is said to be 20 to 30 micro-ohm cm at 68 F and 80 to 100 micro-ohm cm at 1832 F. Has modulus of elasticity similar to ceramic materials. Billed as suitable for lightweight ball and roller bearings for high-temperature, high-performance (jet and rocket) engines; knife edges; metal-spraying equipment, and crucibles, pumps and valves for nonferrous metals. **National Carbon Co, Div Union Carbide Corp, 270 Park Ave, New York 17.**

Circle 307 on Reader Service Card

Straight, reverse-tapered tubing . . .

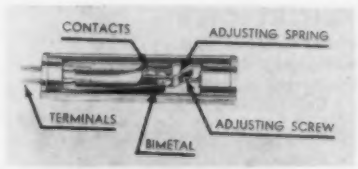
OD range is from .117 to .625 in. and wall thicknesses from .012 to .0625 in. Available up to 10 ft long. Reverse-tapered tubes are furnished in two forms: tapered from middle to both ends and tapered from ends to middle. Straight-tapered tubes are tapered continuously from one end to other. Produced in carbon, alloy and stainless steels; nickel and nickel alloys; beryllium copper; and such reactive metals as titanium and zirconium. **Superior Tube Co, 1556 Germantown Ave, Norristown, Penna.**

Circle 308 on Reader Service Card

Miniature multiple counters . . .

operate at a frequency exceeding 200 kc at less than 2 w per transistor-equipped decade, with electrical reset and optional 10-line coincidence or 1-2-4-8 binary output. Up to eight decades available as complete unit. Numerals are 1 in. high, displayed on ⅜-in. centers. **Robotomics Corp, 2422 E Indian School, Phoenix, Ariz.**

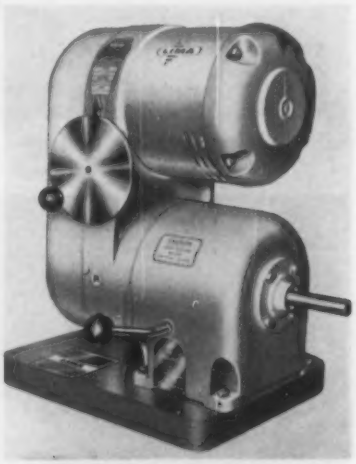
Circle 309 on Reader Service Card



Miniature thermostat . . .

is hermetically-sealed to hold its control temperature to 34.5 F for over 500,000 operations with a resistive load of ½ amp at 26 v, dc. Handles loads up to ½ amp at 115 v/60 c, ac. Set to tolerance of ±33.8 F, it can control small ovens with variations of less than ±33 F over a wide ambient temperature range. Measures 1.325 in. long x .317 in. dia. Shock- and vibration-resistance makes it suitable for electronic apparatus subject to rough treatment. **Instrument Div of Thomas A Edison Industries, McGraw-Edison Co, 61 Alden St, West Orange, NJ.**

Circle 310 on Reader Service Card



High-torque drive . . .

provides infinitely variable output speeds in each of four different transmission ratios. When used with an 1800-rpm motor, unit offers every rpm between 180 and 1800. Using a 1200-rpm motor, all speeds between 120 and 1200 rpm are available. Furnished in either drip-proof or totally enclosed, fan-cooled designs in ¼, ½ or 1 hp. **Lima Electric Motor Co Inc, Lima, Ohio.**

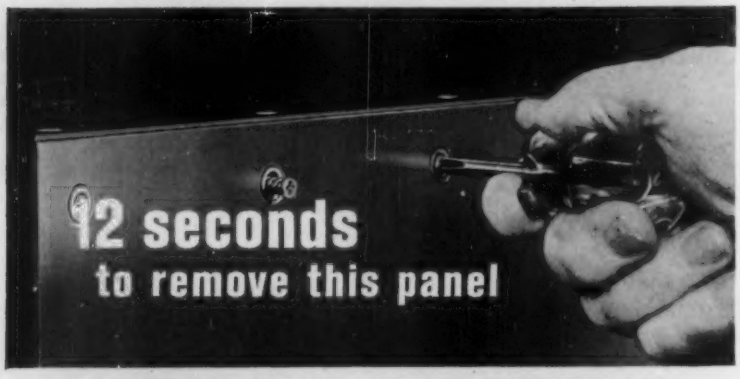
Circle 311 on Reader Service Card

Linear-motion potentiometer's

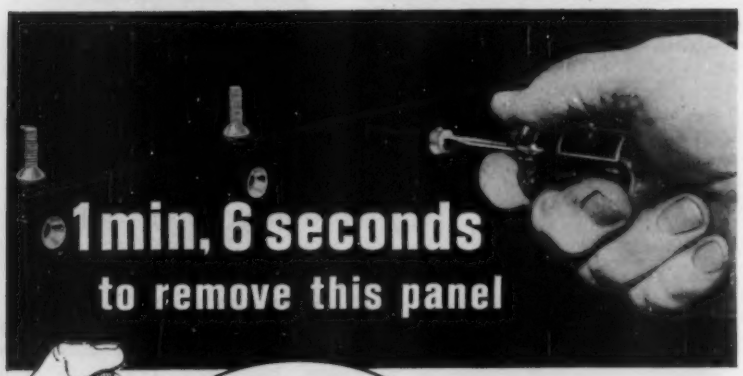
resistive element embodies solid raised track of conductive plastic molded, together with terminals and taps, to phenolic insulator base of matched thermal-expansion coefficient. Conductive plastic track can be provided with wide range of electrical resistivities. Measuring ½ in. dia, unit is suitable as feedback device in such rectilinear actuator servos as valve stem indicators for fluid flow rate and pressure controls. Permits coaxial mounting to meet design configurations in pneumatic and hydraulic systems. Electrical output accuracy is stated at

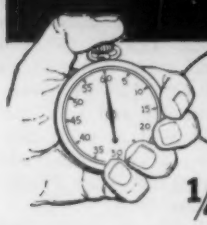
continued on page 94

¼-TURN FASTENERS



VERSUS SCREWS





Designed To SAVE YOU Time

CAMLOC ¼-TURN FASTENERS

The odds are in your favor by 5½-to-1 when you design-in Camloc ¼-turn fasteners. By actual test, you save that much time—compared to screws—in removal and replacement of these panels. What's more, there are no loose parts – Camloc fasteners are "captive" in the mating panels. By all odds, Camloc ¼-turn fasteners cost you less to use, save you time, save you effort in fabrication and service. Millions of fasteners in use today are proof of their outstanding, money-saving qualities. Write today for Catalog.

SOME TYPICAL APPLICATIONS

Aircraft Panels • Electronic Sub-assemblies • Railroad Cars Heavy Machinery • Lighting Fixtures • Missiles • Automotive Equipment • Television Studio Equipment • Transit Cases • Business Machines • Consoles • Collapsible Units

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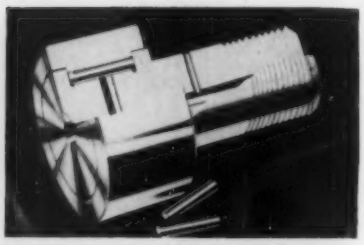
LOS ANGELES, CALIF. • FT. WORTH, TEXAS

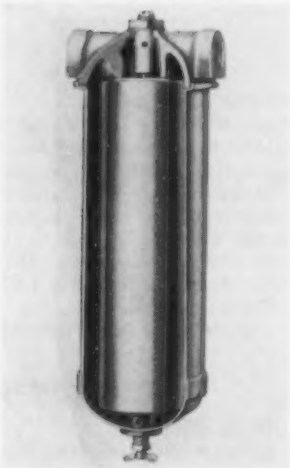
±0.5% or better. Available with element resistences ranging from 1 to 20 k ohm and shaft stroke lengths of 1.587 and .600 in. **Markite Corp, 155 Waverly Pl, New York 14.**

Circle 312 on Reader Service Card



Heavy stud bearings . . . provide high shear strength to accommodate excessive stud deflection in critically loaded track, guide, support and cam-follower applications. Roller diameter on two models start at ½ in.; stud diameters from ¼ in. Capacities range from 470 to 20,750 lb at 100 rpm. Full race width rollers and hardened end plates are said to resist wear under misalignment. **Bearing Div, McGill Mfg Co Inc, Valparaiso, Ind.**

Circle 313 on Reader Service Card



Porous metal filter element . . . made of sintered stainless steel, is designed for corrosive, high-temperature and high-viscosity fluids. Available in 40-, 20-, 10-, 5- and 2-micron particle-retention ratings. Reported to be free from media-migration under high-differential pressures, vibration or thermal shock. Large percentage of voids provides high dirt-holding capacity. **Commercial Filters Corp, 2 Main St, Melrose 78, Mass.**

Circle 314 on Reader Service Card

. . . continued on page 96

1940 1941 1942 1943 194-

Certi-Crimp* • A-MP-O-LECTRIC • Plasti-Grip • SOLISTRAND • Plasti-Bond • AMP-O-MATIC • Amplifilm • AM

4 1945 1946 1947 1948 19

TION • COPALUM • Ampli-Bond • DYNA-CRIMP • TERMALUM • FASTON • AMPLIMAP • CERTI-SEAL • PIDG • A

49 1950 1951 1952 1953

MPOWER • DIAMOND GRIP • AMPORTAPOWER • AMP EDGE • Certi-Crimp • A-MP-O-LECTRIC • Plasti-Grip •

954 1955 1956 1957 1958

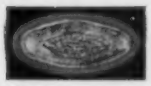
SOLISTRAND • Plasti-B... film • A... Bond • DYNA-C...

RIMP • T... -SEAL • ...PORTAP

*Registered U.S. Patent Office

INDUSTRY LEADERS

BECAUSE IT'S THE CRIMP THAT COUNTS!



All connectors may look alike but when faced with the test of performance . . . contact crimp reliability makes them all different. The big difference between other connectors and the AMPin-cert connector is the snap-in design contact attached to the wire by AMP's precision-controlled, compression-crimp technique. Twenty years of intensified research, development and production stand behind the industry-accepted compression technique which produced Solistrand®, Diamond Grip®, Pre-Insulated Diamond Grip®, Plasti-Grip®, Certi-Crimp® and the more than 15,000 different AMP circuit termination products. This is the common denominator which spells out unquestioned reliability in all our products including the AMPin-cert connector line. ANOTHER AMP FIRST! Now AMP offers tape-fed, automated application of AMPin-cert contacts. Production levels of up to 1,500 terminations per hour can be achieved with standard A-MP-O-LECTRIC® machines. Also, the AMPORTAMATIC crimping tool is available for tape-fed terminations in hard-to-reach locations.

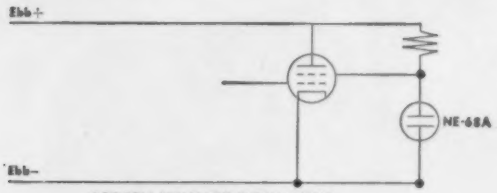
AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • West Germany

1½ Times
Actual Size

SPECIAL G-E GLOW LAMP (NE-68A) HOLDS VOLTAGE VARIATIONS TO LESS THAN 3 V



SCREEN VOLTAGE REGULATOR

Here at last is a glow lamp with true voltage regulation specifications. Within a range of 52 to 65 volts, each individual General Electric NE-68A will not vary more than three volts even though current through the lamp fluctuates between .1 and .3 milliamps. Minimum maintaining voltage of all NE-68A's at .1 milliamps is 52 volts; maximum voltage at .3 milliamps is 65 volts.

The G-E NE-68A is a pre-aged glow lamp with plated leads to make soldering easier. It contains a mild radioactive additive for reduced dark effect. Special treatment with the G-E Dri-film process insures high leakage resistance under humid conditions.

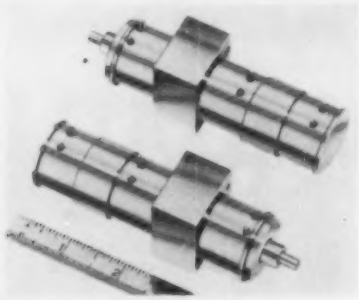
DIRECT CURRENT CHARACTERISTICS

Breakdown Voltage (in light)	60-90 volts d-c
Breakdown Voltage (in dark)	110 volts d-c maximum
Maintaining Volts (.1 to .3 m.a. range)	52-65 volts d-c
Extinguishing Volts (in series with .25 megohm or more)	>50 volts d-c
Design Current	0.1 to 0.3 m.a.
Leakage Resistance at 75% RH and 80°F	100 megohms or more
Life (at .3 m.a. d-c for an average change of 5 volts in maintaining voltage)	2000 hours

There is a General Electric Glow Lamp to fit your circuit requirements. For the latest information on Glow Lamps as Circuit Control Components and Indicators, write for 4-page Bulletin #3-0193. General Electric Co., Miniature Lamp Dept. M-034, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC



Differentially coupled clutches . . .

with integral, antibacklash brake, has input and output shafts and mounting pilot at one end. Input shaft, 0.375 in. dia, can be driven continuously in one direction, while 0.187-in. dia output shaft remains stationary or is driven in either direction depending upon which of three sets of terminals is electrically energized. In event of power failure, brake locks output shaft to housing with zero backlash grip. Made of stainless steel with molybdenum disulphide impregnated sleeve bearings. Coil terminations are located inside 16-oz unit. Normally wound for 24 to 28 v, dc. **Marketing Computers Inc, 50 St. Benedict, Florissant, Mo.**

Circle 315 on Reader Service Card

Rolled-metal strip . . .

is produced in .0001-in. thickness tolerances. Accuracy—said to be ±½ of 1% of thickness—eliminates need for precision grinding and lapping operations and minimizes dimensional rejects. Available in brass, steel, aluminum, titanium, stainless steel and other metals in thicknesses from .0005 to .125 in. and widths up to 6 in. **American Silver Co Inc, 36-04 Prince St, Flushing 54, NY.**

Circle 316 on Reader Service Card

High-strength carriage bolts

are made of high-carbon steel, triple heat-treated. Have tensile strength of over 130,000 psi, compared with a reported 55,000 psi strength for other carriage bolts. **Premier Industrial Corp, 4415 Euclid Ave, Cleveland 3.**

Circle 317 on Reader Service Card

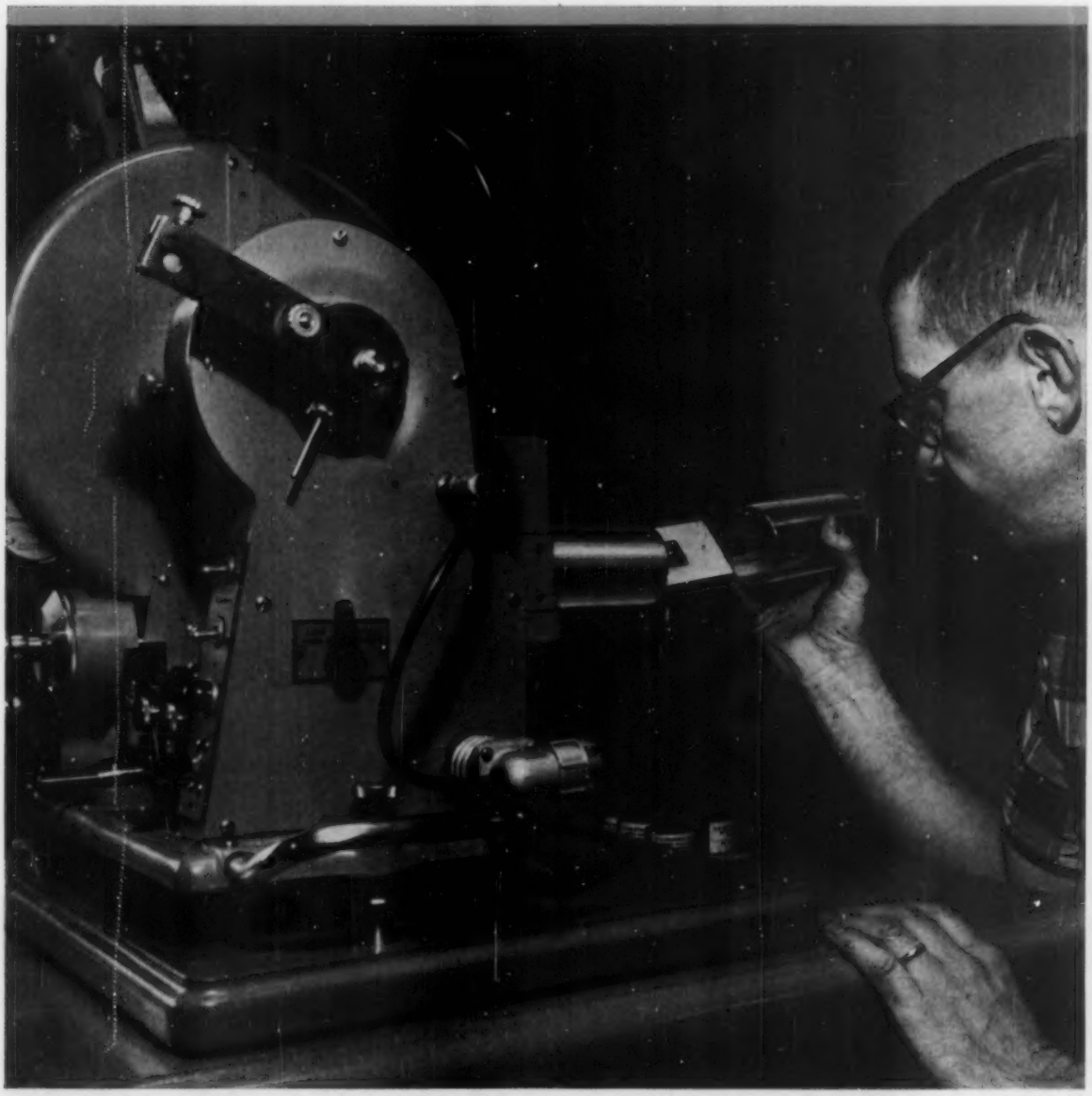
Automatic timer . . .

cycles temperatures between −100 and 500 F and is said to be accurate within ½ F. With timer, temperature chamber completes a cycle in 12 minutes. Allows independent time durations of up to three hr each for any pair of preselected high and low temperatures. Selector switch

continued on page 100

Laboratory facilities at Standard have kept well in step with the revolutionary advances which have been made in the field of metallurgy during the past decade. Plant facilities, too, are geared to produce even the most exotic of special alloys which today's industry demands.

And Standard's famed personalized service means that your most difficult problems can be resolved by our metallurgists and engineers and assures a finished product which meets your most exacting requirements, delivered in record time. Write today for the illustrated booklet, "Quality Control at Standard."



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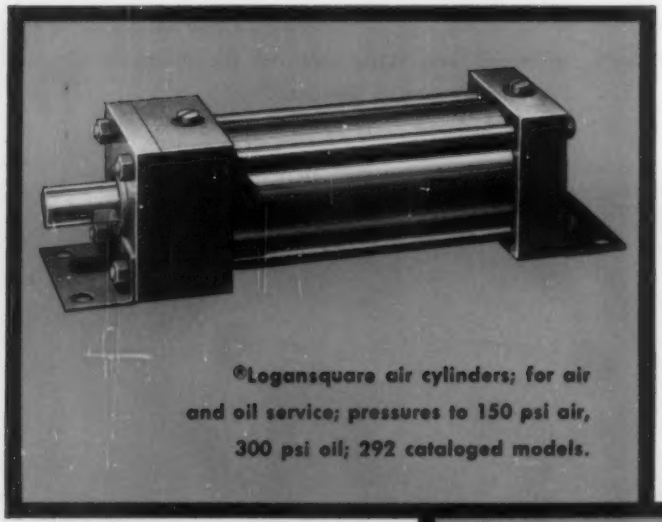

®Logansquare air cylinders; for air and oil service; pressures to 150 psi air, 300 psi oil; 292 cataloged models.

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Of all U. S. Metalworking Plants

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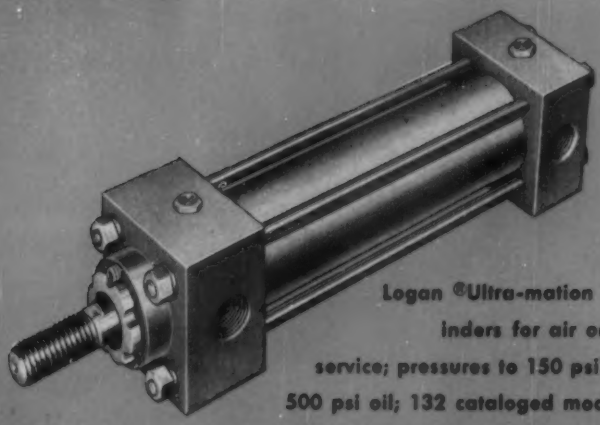
AIR and HYDRAULIC EQUIPMENT

11

Cataloged Lines of Air and Hydraulic Cylinders



Logan ®Ultra-mation cylinders for air or oil service; pressures to 150 psi air, 500 psi oil; 132 cataloged models.

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812 CENTER AVENUE, LOGANSPORT, INDIANA

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- ☐ 200-2 ROTOCAST HYD. CYLS.
- ☐ 200-3 750 SERIES HYD. CYLS.
- ☐ 200-4 AND 200-7 HYD. VALVES
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MEMBER: National Machine Tool Builders' Assn.; National Fluid Power Assn.

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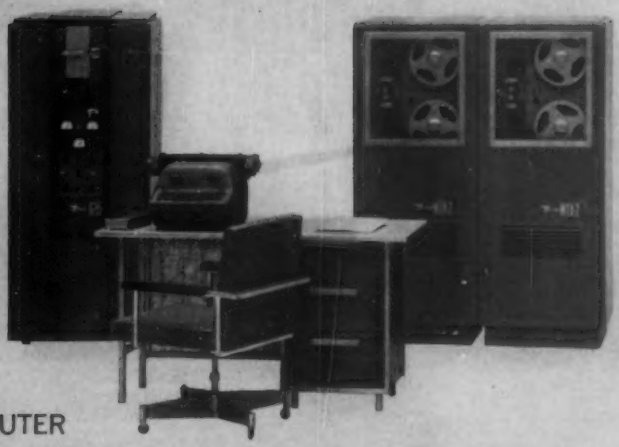

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* AN ALGEBRAIC COMPILER BASED ON INTERNATIONAL ALGOL.

PROBLEM: $$I = \frac{E}{\sqrt{R^2 + (6.2832\,FL - 1/6.2832\,FC)^2}}$$

(For values of R F & L as specified. For values of E ranging from 100 to 300 in increments of 50. For values of C ranging from .00002 to .000021 in increments of .0000001)

COMPLETE ALGO PROGRAM:

```
BEGIN ⑤
R = 10 ⑤
F = 60 ⑤
L = ₀2 ⑤
FOR E = 100(50)300 BEGIN ⑤
FOR C = ₀00002(₀0000001)₀000021 BEGIN ⑤
I = E/SQRT(R ↑ 2 + (6₀2832 * F * L — (1/(6₀2832 * F * C))) ↑ 2) ⑤
PRINT (FL) = E ⑩
PRINT (FL) = C ⑤
PRINT (FL) = I ⑤
```

Write on your letterhead for the self-teaching ALGO manual.

Bendix Computer Division
DEPT. AW-23 LOS ANGELES 45, CALIFORNIA

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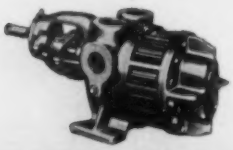
WHATEVER YOUR REQUIREMENTS FOR ROTARY PUMPS, THERE'S A ROPER TO DO THE JOB

Series T .3 to 55 GPM
Choice of 192 Models

Pump and motor units . . . pump serves as end bell of motor. Require minimum space . . . easily installed . . . no coupling required . . . mount in any position. Each unit approximately same size as NEMA motor of HP required for driving. Open drip proof or totally enclosed motors; single or three phase as required.

ROPER
ROTARY PUMPS



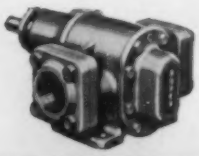
ROPER
ROTARY PUMPS

Series F 1 to 300 GPM
Pressures to 300 PSI

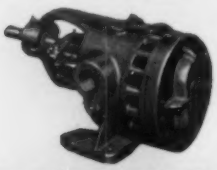
Feature helical steel pumping gears, hardened steel shafts, bronze flange-type bearings. 4-port design with 8 optional piping arrangements (4 for CW and 4 for CCW rotation) solves installation problems. With or without built-in relief valve in either mechanical seal or packed box construction.

Series K ¾ to 50 GPM
Pressures to 150 PSI

Extremely compact in all sizes. Helical pumping gears are hardened steel, with steel shafts and bronze bearings. Sizes 10 through 50 GPM have patented venturi suction and discharge principle for smooth flow and quiet operation. With or without built-in relief valve; packed box or mechanical seal.



ROPER
ROTARY PUMPS



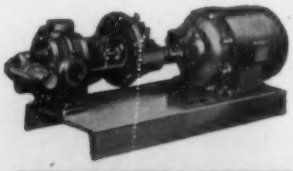
ROPER
ROTARY PUMPS

Series H 5 to 75 GPM
Pressures to 1000 PSI

Designed to operate at direct motor speeds. Used for all types of hydraulic mechanisms where high pressures are required. Hardened steel spur gears for maximum efficiency, and heavy duty roller bearings and bronze wear plates for long life service. Mechanical seal or packed box.

Series 3600 40 to 300 GPM
Pressures to 100 PSI

Handle thick or thin liquids at slow speeds. Operate in either direction. Hardened iron pumping gears, hardened steel shafts, heavy duty bronze sleeve bearings. Mechanical seal or packed box. Series includes tank truck pumps as well as single motor driven units with gear reduction.



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Manufacturers of Standard, Special and Custom Pumps for All Industries

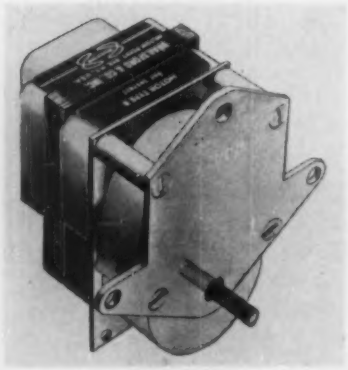
sets intervals to include transition times as well as constant-temperature time. **Delta Design Inc, 7460 Girard Ave, La Jolla, Calif.**

Circle 318 on Reader Service Card

Photoelectric control . . .

comes in flashlight-type cylinder, 7½ in. long x 1⅝ in. dia with a conduit hub threaded for ½-in. pipe. Contains cadmium selenide cell, transistor-equipped amplifier, power transformer and output relay. In relay operation, light impulses as short as 0.015 sec at light-beam ranges up to 20 ft are said to be possible. **Photoswitch Div, Electronics Corp. of America, 1 Memorial Dr, Cambridge, Mass.**

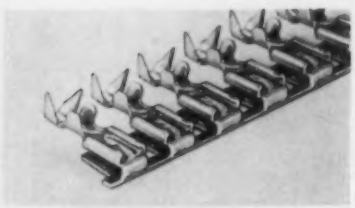
Circle 319 on Reader Service Card



Dc instrument motor . . .

has continuous output torques of 40 oz-in. and intermittent torques of 80 oz-in. at 2 rpm. Power inputs average 80 milliw at no load; 180 milliw at 40 oz-in. at 2 rpm. Contains no revolving windings or sliding mechanical commutators. Standard speeds are from 2 to 200 rpm. Also available without reduction gear at nominal speed of 3000 rpm. Wound for input voltages of 3, 6, 12 and 24 v, dc. **Brailsford & Co Inc, 670 Milton Rd, Rye, NY.**

Circle 320 on Reader Service Card



Double-duty connector . . .

permits multiple connections to same terminal. Includes both a connector, and integral male terminal to which another

continued on page 104

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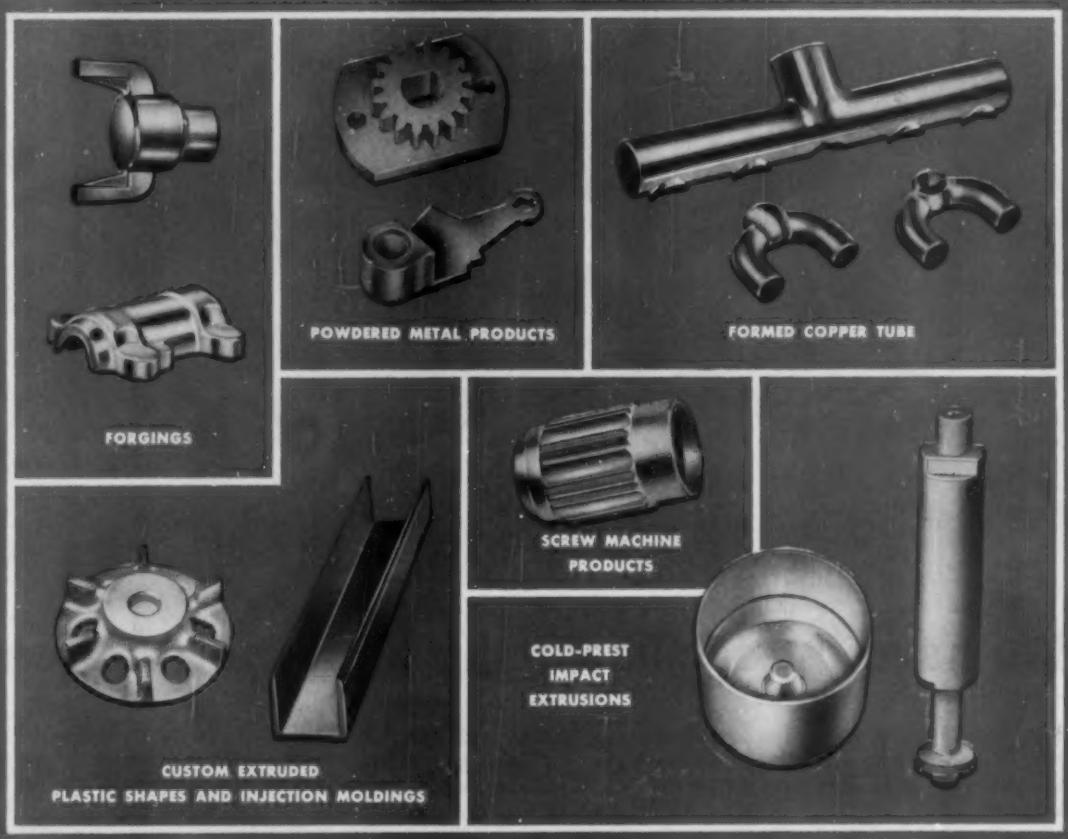

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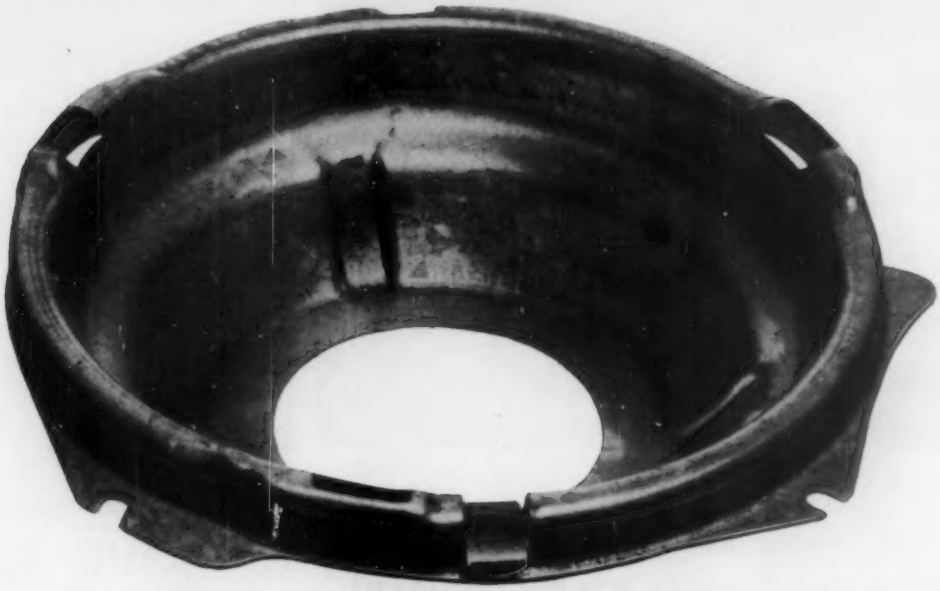

How zinc-coated steel cut 5 steps from automotive lamp housing fabrication.

When automotive head and tail lamp housings were drawn from cold rolled sheet steel and then zinc-plated or painted, as many as five or six handling and cleaning steps were required to make them corrosion-resistant.

Now, fabricated from Weirkote continuous-process zinc-coated steel, the housings go directly from the press to the assembly line. Further processing is unnecessary because Weirkote can be worked to the limits of the steel itself without chipping or flaking its corrosion-resistant zinc surface.

It's this superiority that caused the automobile industry to increase its consumption of zinc-coated steel more than 700% in five years; to use it in such varied applications as mufflers, window channels and the understructures of unitized bodies; to take advantage of developments such as differentially zinc-coated steel that can be welded at top production-line speeds.

A major supplier is Weirton Steel Company—producer of Weirkote continuous-process zinc-coated steel sheets and many other excellent steels that are improving products, methods and profits throughout industry.

Galvanized Steel

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WEIRTON STEEL COMPANY

Weirton Steel is a division of **NATIONAL STEEL CORPORATION**

Weirkote will also be available in 1961 from National's Midwest Steel Division, Portage, Indiana.

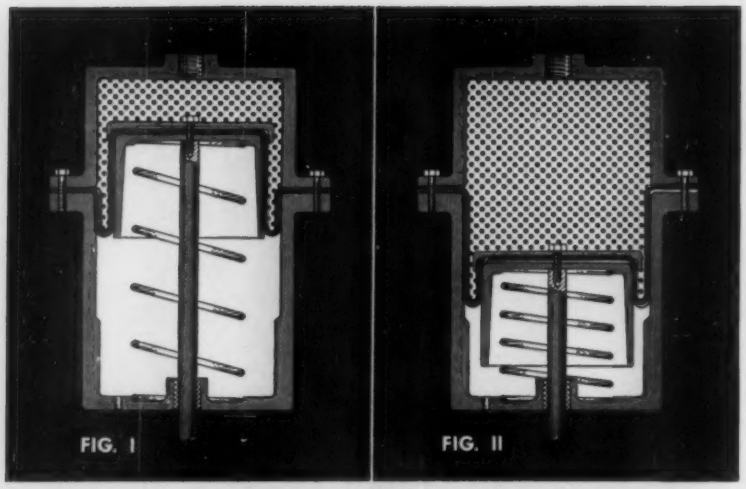

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Fig. I shows how Bellofram Rolling Diaphragm conforms to the piston. Fig. II shows how, as the piston descends under pressure, the diaphragm *rolls* off the piston's sidewall and onto the cylinder's sidewall in a smooth, continuous, frictionless movement.

The Bellofram principle can be applied widely in actuators, pumps, instruments, seals, accumulators, fluid dampers, etc.

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8. Compatibility with practically all environmental gases or fluids.
9. Automatic de-icing action.
10. Free positioning with complete relaxation at any point in its stroke.
11. Does not require close machine finish tolerances on pistons and cylinders.
12. Freedom from abrasive wear.
13. One hundred stock sizes. Four mounting configurations. Special types and sizes designed to order.
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Wide range of working pressures: 1 in. H2O to 500 psi (up to 1200 psi in some cases).

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female connector or double-duty connector can be attached. Crimp-on section accommodates wires in sizes 12 to 18. Made of heavy-gage brass and available individually or in continuous strips for automatic attachment. **Ark-Les Switch Corp, 51 Water St, Watertown 72, Mass.**

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Air-pressure valves . . .

open with less than $\frac{1}{8}$ of a turn. Two-way valves both open and close and are suitable for pressures up to 400 psi. Three-way valves open, close and exhaust up to 125 psi. All have $\frac{7}{16}$-in. max orifices. Available in combinations of $\frac{1}{8}$- and $\frac{1}{4}$-in. male and female pipe ports and $\frac{3}{8}$-in. male pipe ports. **Generant Engineering Co, 260 S 20th St, Newark 3, NJ.**

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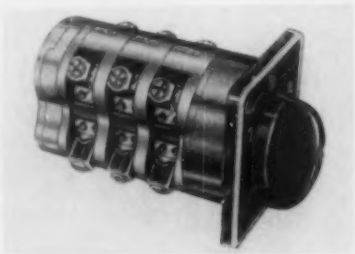


Hp-rated rotary switch . . .

is designed for motor-control and power-switching applications up to 40 hp at 500 v. Current rating is 63 amp, 600 v, ac. Carries two isolated, double-break, silver-alloy contacts in each of 12 stages. Cam-operated contacts can be arranged to open or close as often as required during switch rotation. Standard contact development is available for 90-, 60-, 45- and 30-deg throw. Delivery in 10 to 20 days. **American Solenoid Co Inc, US Highway 22, Union, NJ.**

Circle 323 on Reader Service Card

Pushbutton switch . . .

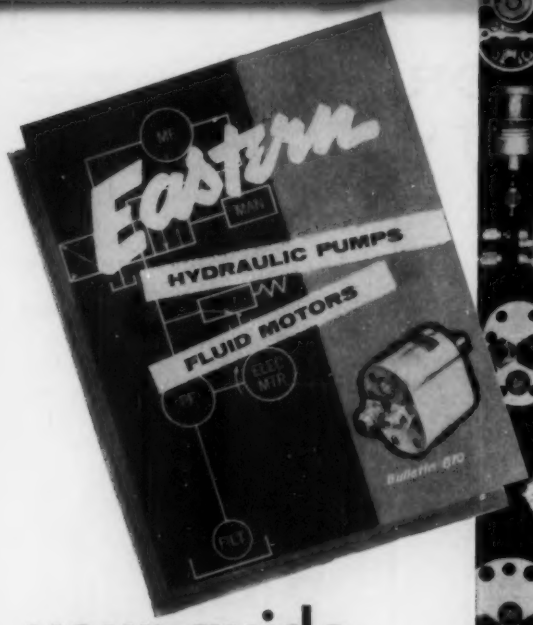
is said to last for a minimum of 25,000 operations at rated load. Available as either 2P2T or four-circuit unit. Fits $\frac{3}{4}$-in. hole and is rated at 2 amp inductive or 4 amp resistive, 28 v, dc. **Control Switch Div, Controls Company of America, Folcroft, Penna.**

Circle 324 on Reader Service Card

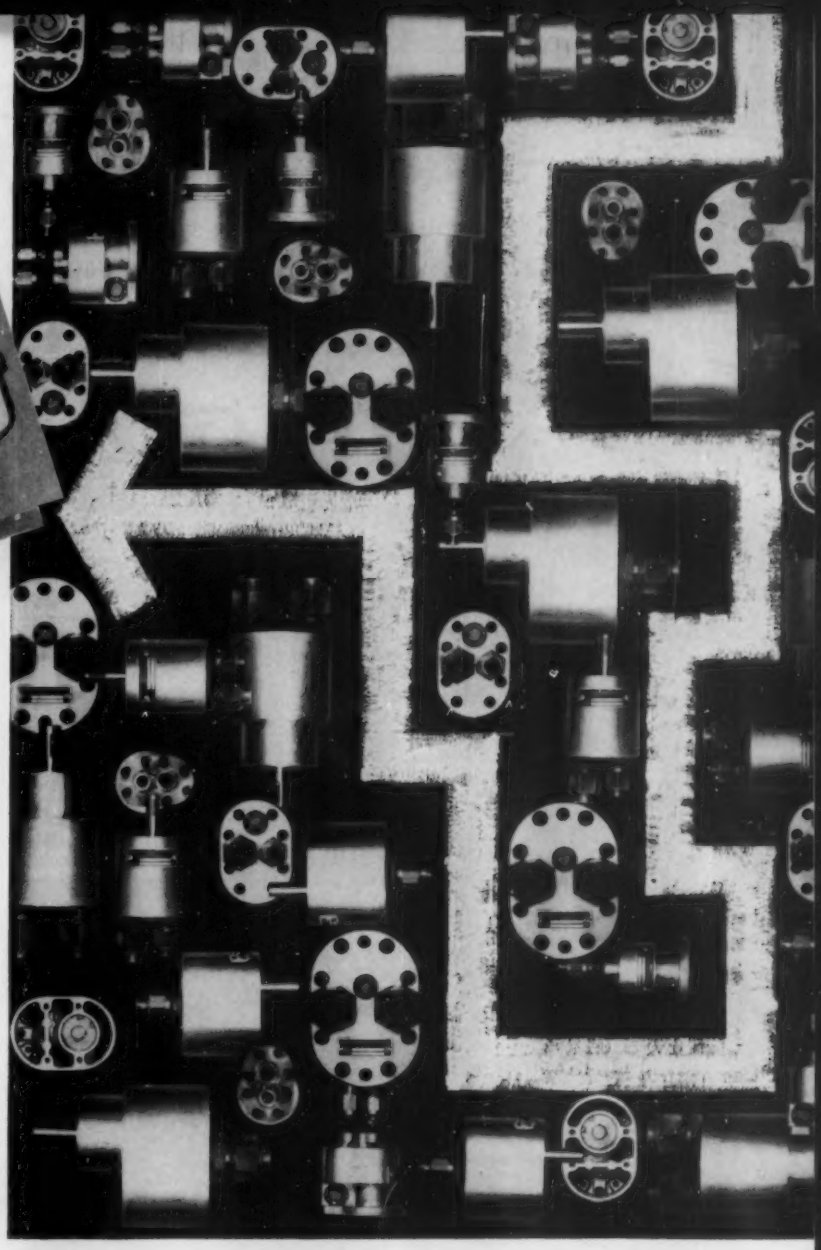
Eight-circuit duplex breaker . . .

fits into same space as four-circuit single-breaker load center. Dual breakers are assembled side-by-side in standard-size case. Mechanically attached to rigid steel back-

continued on page 106



your guide to *the gear pump* for your application



This new catalog is an invaluable directory to no less than 129 pump-and-electric-motor-combinations — any and all available off-the-shelf!

Searching for gear pumps with top volumetric efficiencies? Do your performance requirements fall into one of these three major groups?

- Eastern 1200 series — up to 1.6 gpm — pressures to 800 psi
- Eastern 100 series — up to 5 gpm — pressures up to 1500 psi
- Eastern 700 series — up to 9.8 gpm — pressures up to 1500 psi

If one or more of these performance ranges measures up to what you need, save hours of searching your way through the gear pump maze — send for catalog 810 now!

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- **positive displacement pumps**
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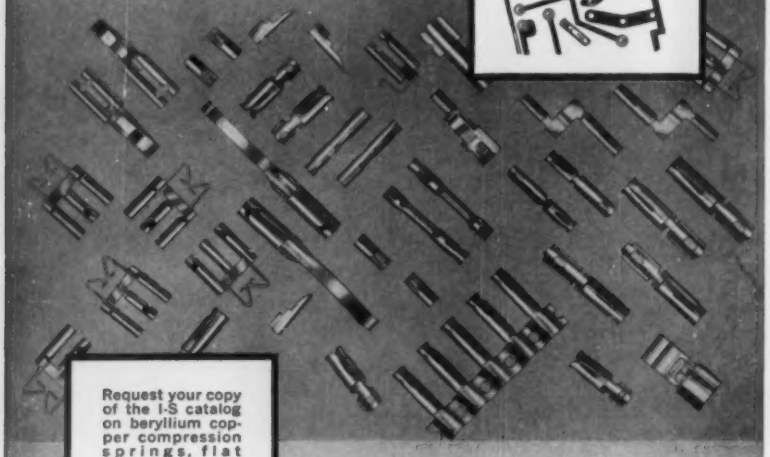

Request your copy of the I-S catalog on beryllium copper compression springs, flat springs, strip springs, contact strips, contact rings and screw machine parts. Send drawings and specifications for quotations on your specific requirements.

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plate, independent of the urea-plastic breaker case. Thus, mechanism can be dropped into case during assembly operations rather than assembled in case. Available in three combination ratings: 15 and 15 amp, 15 and 20 amp, and 20 and 20 amp; all at 120/240 v ac. **Bryant Electric Co, Bridgeport 2, Conn.**

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with 8-in. pneumatic tires are designed for low-speed, light-duty industrial and agricultural operations. Stamped-drop center rims and hub are welded into one assembly. Hub and bearing diameters start at $\frac{5}{8}$ in. Hub lengths are available up to $7\frac{1}{2}$ in. **French & Hecht Div, Kelsey-Hayes Co, Detroit 32.**

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One-lamp diazo whiteprinter . . .

has fingertip dial-speed controls which eliminate gear changing. Makes sepias and foils as well as whiteprints. Printing unit and transparent developing tube can be mounted on office wall. Five models are available, taking any length paper in widths of 18, 27 and 42 in. Prices start at $129.50. **Rotolite Sales Corp, Stirling, NJ.**

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Portable, variable transformer

features an "overvoltage, no-overvoltage" selection switch which limits max output to line voltage (120 v) or to overvoltage rating (140 v). Transformer face carries two voltage calibration sets in two different colors to match output indications on selector switch. Carrying handle also serves as easel. Rated at 7.5 amp and incorporates protective circuit breaker. Price of one through five units, $28.50. **Ohmite Mfg Co, 3627 Howard St, Skokie, Ill.**

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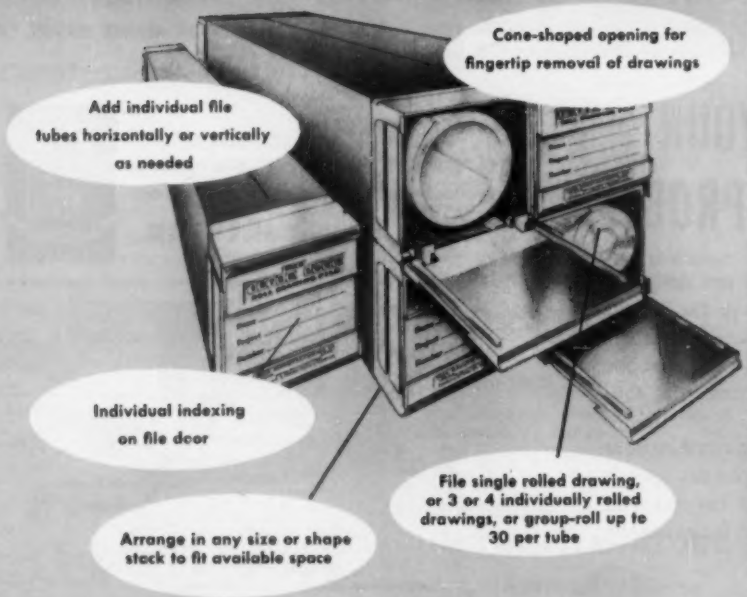
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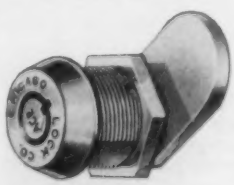

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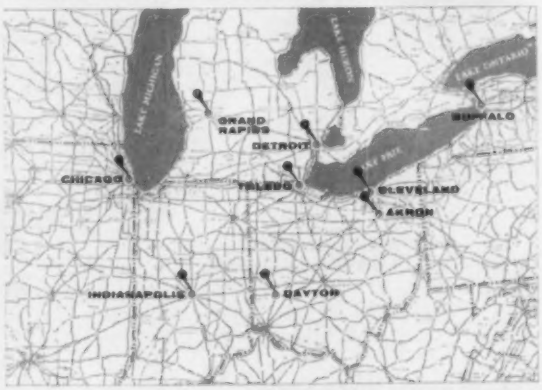

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DESIGN LITERATURE

Synthesis of New High-temperature Materials

PB 161720. Engelke, Halden, Farley. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ x 11, 39 pp. $1.25.

Melting points of promising high-temperature structural materials (borides, carbides, and oxides) are tabulted in this Stanford Research Institute report to Wright Air Development Div. High-temperature champion is still hafnium-tantalum carbide (melting point: 7150 F), but the study uncovered nearly a dozen compounds with melting points of 6000 F or more; and at least one, a molybdenum carbide-molybdenum boride composition, with unusual ablation properties. On the other hand, chemical and metallurgical investigations have led the SRI researchers to the reluctant conclusion that the hafnium-tantalum compound is likely to retain its championship. It is unlikely, they say, that compounds melting above 7200 F can be found.

Digital-computer Fundamentals

THOMAS C BARTEE. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 6¼ x 9¼, 342 pp. $6.50.

Another book that provides the background needed to understand digital computers; better arranged than many, not so engagingly written as some. Today, if you want to know what a digital computer is and how it works, you have your choice of at least five books currently on the market; they all cover the same ground in about the same depth and assume about the same degree of reader sophistication. This one's not much different than the rest of the lot except for two deviations from the standard routine. First, there's a chapter on programing near the beginning of the book—before the author brings in binary numbers, or basic computer elements such as accumulators, storage devices, control circuits and input-output equipment. And second, there's a chapter on logical design in the middle of the book in which the author explains in some detail Boolean algebra and its application to computer design. No pictures, but a number of sketches which complement the author's clear, but not very compelling prose.

"Good . . . finished three days ahead of schedule . . . let's keep it quiet for another week . . . have to show the brass what a tough job they gave us."

Other Books of Interest

A Survey of Solid-state Light Amplifiers and Allied Devices

PB 161465. Justin Ruhge. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 60 pp. $1.75.

Unified Screw-thread Standards

ASA B1.1-1960. American Society of Mechanical Engineers, 29 W 39th St, New York 18. 8½ x 11, 148 pp. $5.

Status Report on Pressurized Water Reactors as of 1959—Part III, Book 2

TID-8518(2). Superintendent of Documents, US Govt Printing Office, Washington 25, DC. 86 pp. $1.25.

A Visit With '500' Die-cast Plants

E A Day. American Charcoal Co, 201 S Green St, Detroit 17. 600 pp. $10.

ABSTRACTS FROM THE LITERATURE

Maxima, Minima Problems

One of the most useful applications of the differential calculus is in the determination of maxima and minima, but in the solution of practical problems the best approach is not always known. For example, it is not usually appreciated that partial differentiation (which is not as difficult as it sounds) may shorten the calculations. This

continued on page 110

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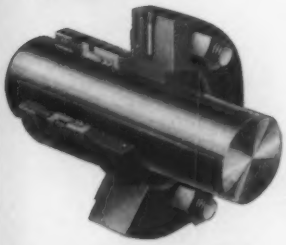

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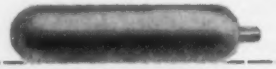

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article discusses the best method of solving problems in maxima and minima and evolves certain new principles.

"Shortcuts to Maxima, Minima Problems," by W H Sheppard. Design Engineering, Sep '60, 481 University Ave, Toronto 2, Canada.

Use of Computers by Small Companies

Author attempts to cover various means of obtaining economical results with computers both on a service basis and through purchase and installation.

"Use of Computers by Small Companies," G A Wesley. Presented at 1960 Western Engineering Conference, American Society of Tool and Manufacturing Engineers, 10700 Puritan Ave, Detroit 38.

Testing Structures for Elevated-temperature Service

A description of the testing methods developed by the authors for various kinds of aircraft structures is given, together with their reasons for using these particular methods and equipment.

"Testing Techniques for Elevated-temperature Structures," Shaw and Stevenson, Douglas Aircraft Co. SAE paper 2288, 485 Lexington Ave, New York 17.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number of postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 115.

COLOR-CODED PUSHBUTTONS – Bulletin 100-1-960, 8 pp. Available combinations of seven colors for coding both buttons and ferrules in control units are shown. Describes and illustrates component parts of pushbutton, selector switch, standard pilot light and push-to-test pilot light or lighted pushbutton units. Clark Controller Co, 1146 E 152nd St, Cleveland 10.

Circle 350 on Reader Service Card

UNIVERSAL JOINTS—Bulletin, 3 pp. Presents specifications of universal sockets and joints in ½- and ¾-in. drive sizes. Hague Mfg Co, 1643 Massillon Rd, Akron 12.

Circle 351 on Reader Service Card

VARIABLE-SPEED DRIVES – Bulletin 551, 8 pp. Tabulates hp and speed ranges to select proper drive for applications with increased torque at high or low speeds. Explains in diagrams and formulae how variable speeds are obtained. Graham Transmissions Inc, Menomonee Falls, Wis.

Circle 352 on Reader Service Card

COLD-HEADED FASTENERS – Bulletin S-100, 4 pp. Pictures sizes available in job-designed rivets, nails, threaded parts, and double-headed parts. Discusses materials savings and structural strength resulting from cold-heading. John Hassall Inc, Box SF, Westbury, NY.

Circle 353 on Reader Service Card

TEFLON SPHERICAL BEARINGS– Catalog 460, 4 pp. Tabulates dimensions and dynamic-load ratings of three illustrated series. Charts average bearing life. Radial Bearing Corp, Taylor St, Danbury, Conn.

Circle 354 on Reader Service Card

LEAD FOR SOUND INSULATION– Engineering report, 12 pp. Treats advantages of using lead to block sound. Calculates and plots effect of adding sheet lead to existing partitions. Lead Industries Association, 292 Madison Ave, New York 17.

Circle 355 on Reader Service Card

SERVOSYSTEM COMPONENTS–Catalog 75, 30 pp. Lists specifications and prices of over 125 synchros, ac and dc motors, servomotors, inverters, actuators, geared motors, generators, etc. Includes curves of servomotors, circuit diagrams and schematics. Surplus Div, Servo-Tek Products Co, 1086 Goffle Rd, Hawthorne, NJ.

Circle 356 on Reader Service Card

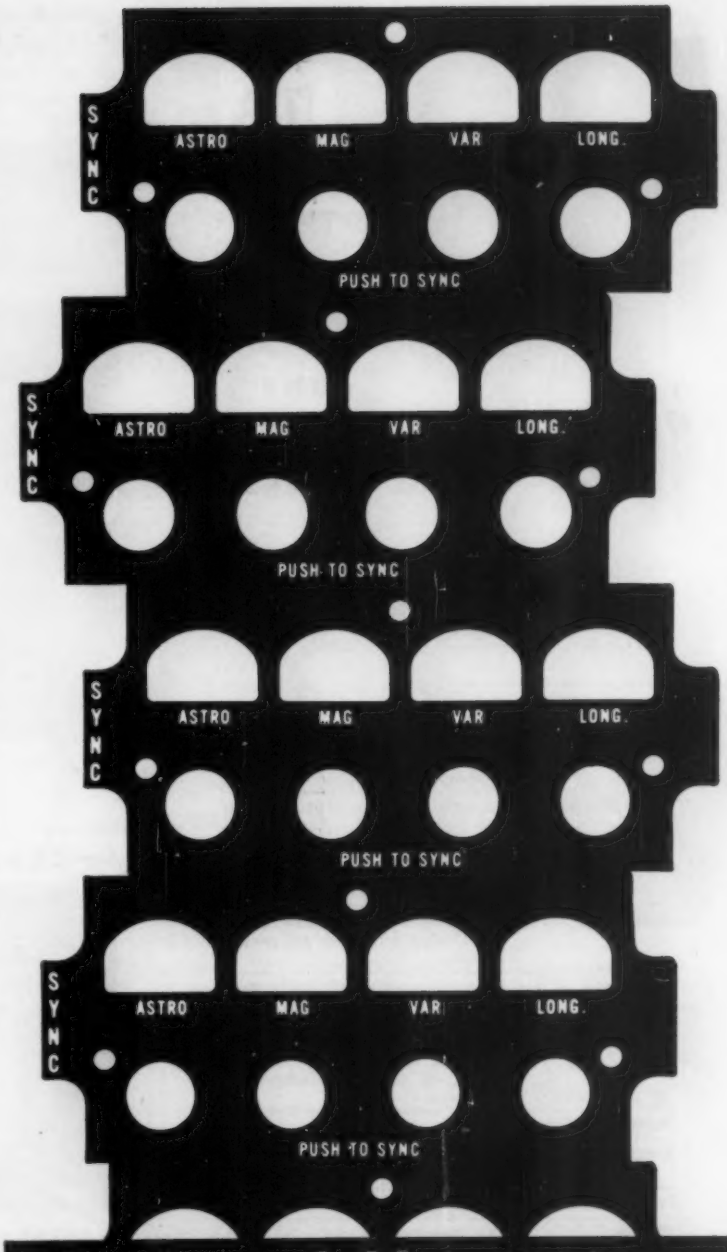
INDUSTRIAL WIRE CLOTH–Bulletin 115, 6 pp. Illustrates 12 types and sizes. Defines terms most frequently used in specifying wire cloth. Cambridge Wire Cloth Co, Cambridge, Md.

Circle 357 on Reader Service Card

GAS TURBINES–Bulletin GED-5685, 15 pp. Graphically presents data on operating conditions, duct losses and torque output of two models. Discusses and illustrates applications in emergency generator sets, hydrofoil boats, gas-line pumping

continued on page 113

"Of course I'm tolerant . . . 'Every idiot to his own opinion,' I always say!"



the shape of things to come

. . . embedded-circuit instrument panels from United States Radium Corporation—one of four new designs incorporating potted circuits for reliability in a variety of industrial and military applications. / These new Lackon panels feature solder-connected wire circuits with "built-in" protection against physical and environmental effects. All wiring is fitted into specially-grooved slots which are then filled, and the panel back finished to provide a smooth, virtually trouble-free surface. / Investigate these longer-lived panels for your critical design needs.

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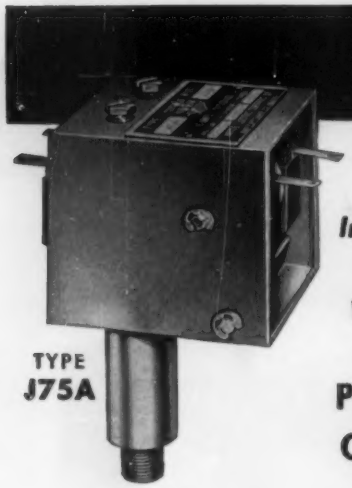
MORRISTOWN, N. J. | Offices: Chicago, Illinois and North Hollywood, Calif. Subsidiaries: Radelin Ltd., Port Credit, Ont., Canada and U. S. Radium Corp. (Europe), Geneva, Switzerland



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Control TWO Independent Circuits With Only ONE PRESSURE CONTROL

TYPE J75A

The Type J75A Dual Switch Pressure Control is a unit that has become increasingly popular because of its many unique features. This control contains two completely separate switches that operate independently of each other, controlling two independent circuits with extreme flexibility of switch arrangement. Pressure settings are individually made by independent adjustment screws that are easily accessible.

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Switch Ratings	To 15 amps. at 115 or 230 volts A.C. Also available are 20 amps. A.C. D.C. switches also available.
Switch Types	Normally Open, Normally Closed or Double Throw — no neutral position.
Adjustments	Pressure settings individually made by independent adjustment screws located on top of switch bracket. Switches may be set together to simulate double pole circuitry or set apart to obtain independent operation.
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Electrical Connections . .	Lead wires attached to screw type terminals on switches.
Pressure Connection . .	Via a ⅛" male NPT connection.
Mounting	Via pressure connection.
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UNITED ELECTRIC ***manufactures a complete line of temperature, pressure, and vacuum controls. For applications requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Complete data is available for the J75A as well as for all standard UE controls.***

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stations, oilwell fracturing units and off-highway vehicles. General Electric Co, Schenectady 5, NY.

Circle 358 on Reader Service Card

SUBMINIATURE TRIMMING POTENTIOMETERS—Folder, 4 pp. Outlines functions, specifications and capacities of eight types. Provides typical installation drawings. Schweber Electronics, 60 Herricks Rd, Mineola, NY.

Circle 359 on Reader Service Card

NICKEL-COATED TUBULAR STEELS—Brochure, 8 pp. Discusses advantages of nickel-alloy-bonded steel pipe and tubing in combatting corrosion and iron contamination. Test-data chart cites coating's corrosion-resistance under varying temperatures. Nickel-Over-Steel Div, M L Sheldon & Co Inc, 350 Lexington Ave, New York 16.

Circle 360 on Reader Service Card

CAST-TOOTH SPROCKETS—Booklet 2867, 12 pp. Covers arm-center, plate-center, segmental, and split-rim sprockets and traction wheels from stock. Over 130 different chain numbers are listed and cross-referenced to 48 sprocket lists. Link-Belt Co, Dept PR, Prudential Plaza, Chicago 1.

Circle 361 on Reader Service Card

LINEAR, ANGULAR ACCELEROMETERS—Bulletin B-4, 4 pp. Describes and illustrates nine types with excitation frequencies from 400 to 10,000 cps and acceleration ranges from ±.1 G to ±700 G. Schaevitz Engineering, Rt 130 at Schaevitz Blvd, Pennsauken, NJ.

Circle 362 on Reader Service Card

CONTROL PILOTS—Bulletin GEA-7302, 8 pp. Tabulates ratings and nomenclature of pressure governors and switches, including pressure and vacuum, plugging and antiplugging, float, pilot and manual-reversing types. Includes dimensional drawings and typical connection diagrams. General Electric Co, Schenectady 5.

Circle 363 on Reader Service Card

STAINLESS STEEL SLEEVES—Size and price list, 2 pp. Covers two types in 63 stock sizes for use as sleeves, liners or wearing rings. Foundry Div, Vollrath Co, Sheboygan, Wis.

Circle 364 on Reader Service Card

TEMPERATURE CONTROL—Bulletin 109, 2 pp. Discusses operation of indicating differential-expansion-type control. Includes photos and dimensional drawing and tabulates standard ranges, tube sizes and performance. Burling Instrument Co Inc, 16 River Rd, Chatham, NY.

Circle 365 on Reader Service Card

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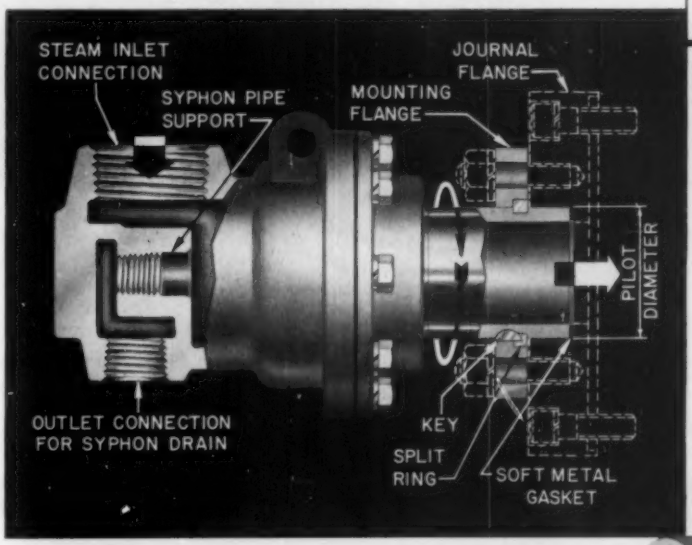
Designed for

EASY INSTALLATION

and accurate control of concentricity



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EASY INSTALLATION—Only an end wrench is required to draw up or loosen four nuts on the mounting flange studs for installation or easy removal of joint.

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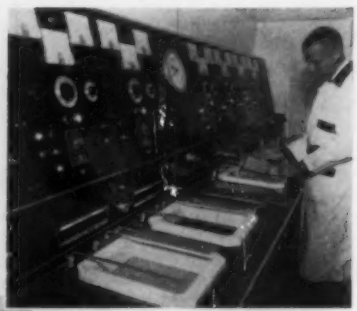

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DESIGN LITERATURE.....continued

POWER SOURCES AND CONVERSION—Catalog 60a, 6 pp. Reviews characteristics and specifications of solid-state sine-wave inverters; low-voltage transistor-regulated, high-voltage fully transistorized and modular transistor-regulated power supplies; and five solid-state power converters. Power Sources Inc, Burlington, Mass.

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MINIATURE THREADS—Price list 1060, 2 pp. Gives prices of stock screws and nuts as small as 0000-160 and round washers in 000 to 2 sizes. J I Morris Co, 394 Elm St, Southbridge, Mass.

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COATINGS CONSULTANT—Booklet, 8 pp. Discusses role of consultant in formulating and testing coatings for manufacturers and users. Foster D. Snell Inc, 29 W 15th St, New York 11.

Circle 368 on Reader Service Card

INDUSTRIAL CORDS—Catalog, 8 pp. Covers sizes, colors, strength ratings of nylon, dacron, linen, cotton, polyethylene and fiberglass cords and threads. Sunset Line & Twine Co. PO Box 691, Petaluma, Calif.

Circle 369 on Reader Service Card

ELECTRICAL CONNECTORS—Bulletin B81, 4 pp. Illustrates and gives specifications and suggested applications for standard and custom-built connectors. Joy Mfg Co, Electrical Products Div, 1201 Macklind Ave, St Louis 10.

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HOSE GUIDE—Bulletin 627, 12 pp. Alphabetically lists 112 liquids and gases and indicates hose styles as excellent, good, conditional or unsatisfactory for use with those agents. Pressure, temperature and size limits of hose types are charted. Aeroquip Corp, Jackson, Mich.

Circle 371 on Reader Service Card

STRIP-HANDLING ROLLS—Bulletin 601, 4 pp. Cutaway drawings depict standard designs available in fabricated steel, cast iron, cast alloy, ductile iron, stainless steel or bimetal construction which can be rubber or plastic-covered or chrome-plated. Discusses use of self-centering rolls in overcoming tracking problems. Barclay Machine Inc, 784 Euclid St, Salem, Ohio.

Circle 372 on Reader Service Card

OIL BYPASS RELIEF VALVES—Catalog supplement, 4 pp. Gives specifications of three standard models, along with recommended uses for optional parts. Fulflo Specialties Co Inc, 440 Fancy St, Blanchester, Ohio.

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HIGH-SENSITIVITY SWITCH—Data sheet 180, 2 pp. Covers mounting dimensions, operating characteristics and electrical rating of subminiature switch for close control sensitivity or response. Micro Switch, Div of Minneapolis-Honeywell Regulator Co, Freeport, Ill.

Circle 374 on Reader Service Card

CONTACTORS AND STARTERS FOR LOW HP USE—Bulletin GEA-7304, 4 pp. Describes and depicts construction features of Size 00 device for fans, blowers, conveyors and small pump motors with up to 2 hp, 550 v. General Electric Co, Schenectady 5.

Circle 375 on Reader Service Card

RESEARCH FACILITIES—1960 directory, 280 pp. Lists more than 1000 commercial and private industrial research and testing labs in New York state; their special research fields; executives' names; and number of scientists and engineers employed. New York State Dept of Commerce, 112 State St, Albany 7, NY.

Circle 376 on Reader Service Card

RECORDERS, INDICATORS—Catalog C15-1a, 48 pp. Gives design and construction features, options and specifications of strip and circular chart recorders and precision indicators. Also discusses measuring elements. Schematics show basic measuring circuits. Minneapolis-Honeywell Regulator Co, Industrial Div, Wayne & Windrim Aves, Philadelphia 44.

Circle 377 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

DIGITAL SPEED-MEASUREMENT SYSTEMS—Bulletin 2000, 6 pp. Discusses proper selection and operation of magnetic and photo-electric pickups, electronic tachometers and in-line readouts, built to withstand moisture, temperature and vibration problems. Provides specifications for both explosion and non-

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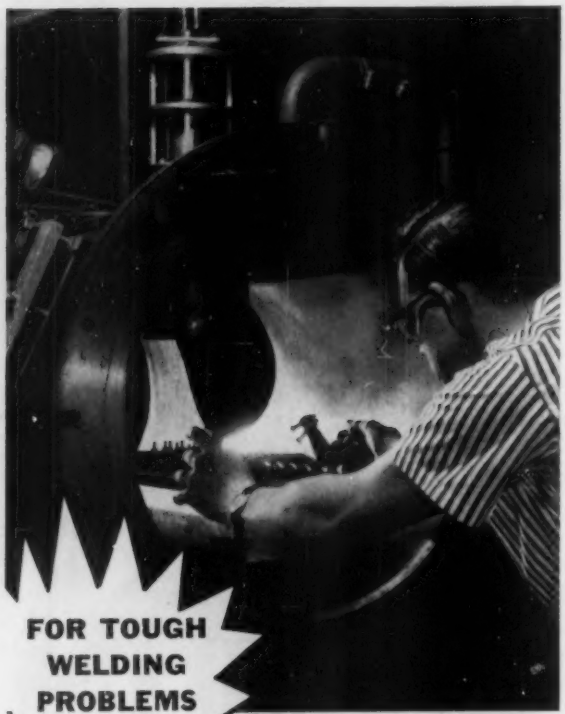

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REC

ROSEMOUNT ENGINEERING COMPANY

4900 West 78th Street • Minneapolis 24, Minnesota

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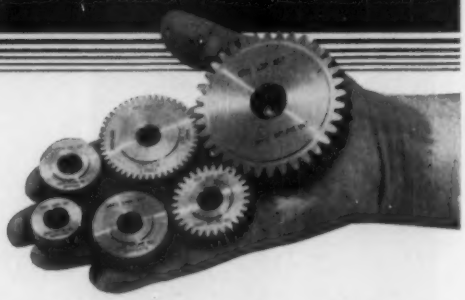

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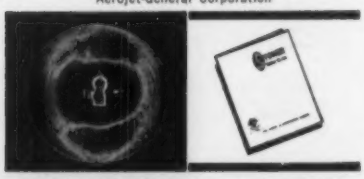
*SMR is a special Silicone Modified Rubber produced by Stoner Rubber Company, Inc.

Photo of Rocket Chamber courtesy of Aerojet-General Corporation



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explosion proof models. Meriam Instrument Co, Electronic Div, 10920 Madison Ave, Cleveland 2.

ADHESIVES, COATINGS, SEALERS—Catalog A-ZBD-102-JR, 8 pp. Foldout tables review uses, characteristics and general properties of over 170 adhesives, coatings and sealers. Cross-reference index lists 200 applications. Minnesota Mining and Mfg Co, 900 Bush Ave, St Paul 6

FOR MORE CATALOGS AND BULLETINS

. . . '1600' of 'em—see your copy of Product Engineering's Mid-Sep 1960 Design Digest. There you will find helpful design literature, classified under 10 different headings, from important manufacturers and suppliers of components, materials, power and control systems, manufacturing processes.

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LATEST RESEARCH SHOWS HOW V-RINGS WEAR

. . . a Palmetto® Engineering Report

The generally unrecognized major cause for V-ring failure—and the need for improved adapters—has been identified in a Palmetto research program under way since 1959.

V-packing wear usually shows first as loss of material in the sealing ring farthest from the pressure medium (the ring adjacent to the female adapter). This is followed by progressive failure of the succeeding rings, resulting in breakdown of the set. The pattern is commonly accepted as normal—induced by uneven distribution of pressure through the set, scuffing, or lack of lubrication.

Now Palmetto testing and examination of worn sets show that the major cause of failure is extrusion and resultant "nibbling" loss of material. Portions of the top sealing ring pass through the gap between the female adapter and the surface sealed. Then, as succeeding rings are no longer adequately supported, each in turn is deformed into the space vacated above.

The obvious remedy is to eliminate the extrusion gap around the female adapter—an impossible goal when using previous types of adapter. Rigid metal or phenolic adapters would require zero tolerance production and perfect surface finishes on both the adapters and the surface sealed. Soft adapters have sufficient flexural characteristics to conform to the sealed surface, but lack the resistance to flow which they must have to prevent extrusion and give proper support to the packing set.

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Guided by these findings, Palmetto Engineering now presents Sealsaver Adapter Rings. Sealsaver material offers the great strength of a phenolic laminate, combines it with the characteristic of flexing slightly under load—so that adapters conform precisely to adjacent surfaces and completely prevent extrusion.

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No. 20 of a series

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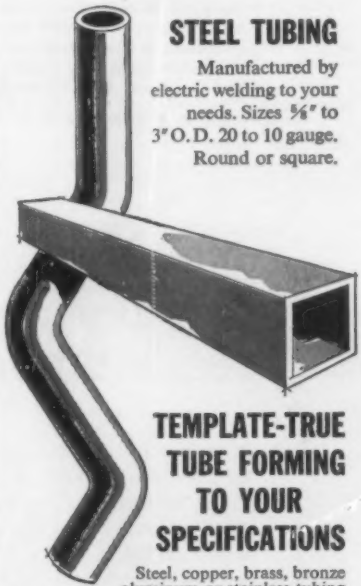

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7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P49 P50 P51 P52 P53 P54 P56 P58 P59 P60
P61 P62 P64 P65 P66 P67 P68 P69 P70 P71

*MULTIPLE PRODUCT ADS
Key No. Specific Product
_____ _____
_____ _____
_____ _____

(please print or type) *If this is change of address, check box* ☐

Name ..... Title .....

Street .....

City ..... Zone ..... State .....

Company ..... Major Product Manufactured .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P49 P50 P51 P52 P53 P54 P56 P58 P59 P60
P61 P62 P64 P65 P66 P67 P68 P69 P70 P71

*MULTIPLE PRODUCT ADS
Key No. Specific Product
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New 3 way Bulletin 8317 with full ¼" diameter exhaust orifice provides quick venting of pressure from cylinders and diaphragms . . . assures the fastest cylinder or diaphragm return of any valve its size. It takes the place of larger, more expensive valves . . . eliminates need for connecting a separate quick vent valve in the circuit to speed up the exhaust cycle.

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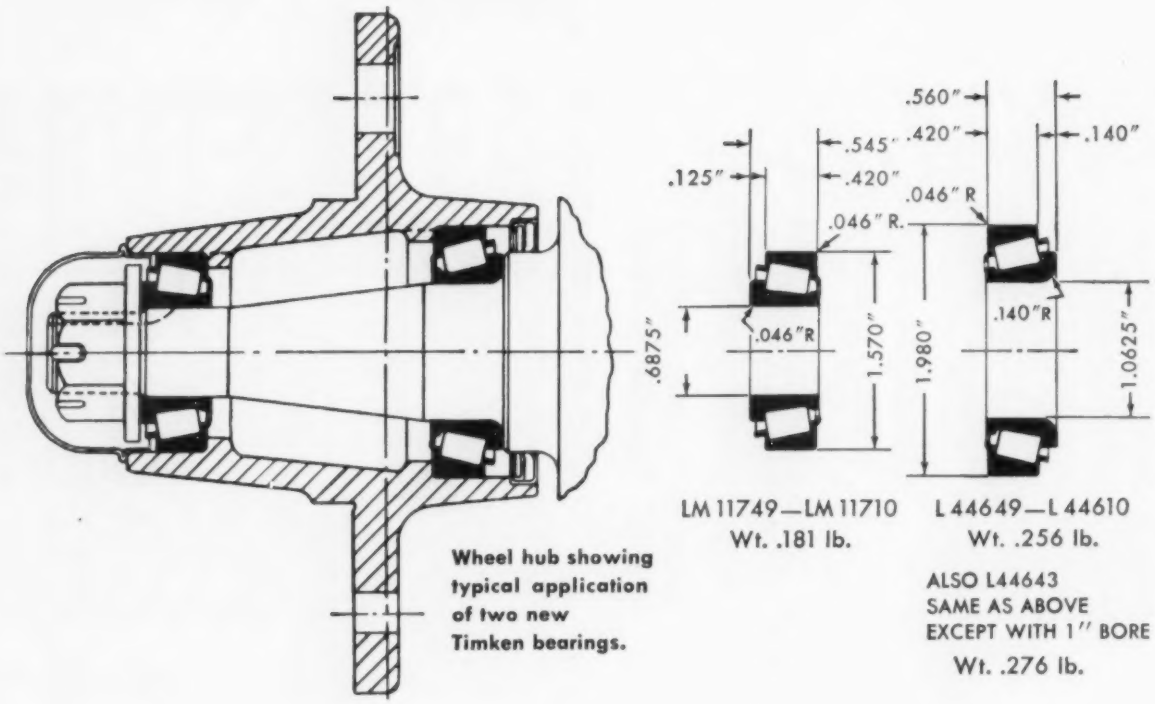
Three new, low-cost TIMKEN® bearings open new design opportunities



Wheel hub showing typical application of two new Timken bearings.

LM 11749—LM 11710
Wt. .181 lb.

L 44649—L 44610
Wt. .256 lb.

ALSO L44643
SAME AS ABOVE
EXCEPT WITH 1″ BORE
Wt. .276 lb.

WITH three new small size Timken® bearings, machine designers can now get the advantages of tapered roller bearings where they couldn't be used before. These new, smaller bearings pack high capacity in less space, and they're lower in cost. They permit more compact designs by keeping related parts smaller—provide additional savings in hub materials, seals, nuts and dust caps.

Diagram above at left shows two of them in a typical layout of a front wheel hub for the Automotive Industry's new compact cars. They're the most economical single-row Timken bearings ever produced in bore sizes of 1 1/16″, 1″ and 1 1/16″. Diagram above at right shows principal dimensions and weights.

Like all Timken bearings, these new Timken tapered roller bearings are geometrically designed and precision-made to roll true. Their taper lets them take *both* radial and thrust loads in any combination. And full-line contact between rollers and races provides extra load-carrying capacity.

Our Sales Engineers will gladly give you complete data, help you design the new bearings into your machines. Timken bearings make any machine better. ***When you buy Timken bearings you get*** *... 1) Quality you can take for granted. 2) Service you can't get anywhere else. 3) The best-known name in bearings. 4) The pace setter in lower bearing costs.* The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ontario.

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tapered roller bearings

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